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POUR L'EXPLORATION DE LA MER

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VOL. VI · NO. 3

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E. S. RUSSELL

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

DÉCEMBRE 1931

Note.

The Journal of the Council will in future appear *three times a year*, and three numbers will form a volume. It will include, in addition to general articles, reviews and bibliography, the special papers hitherto issued in the series of "Publications de Circonstance".

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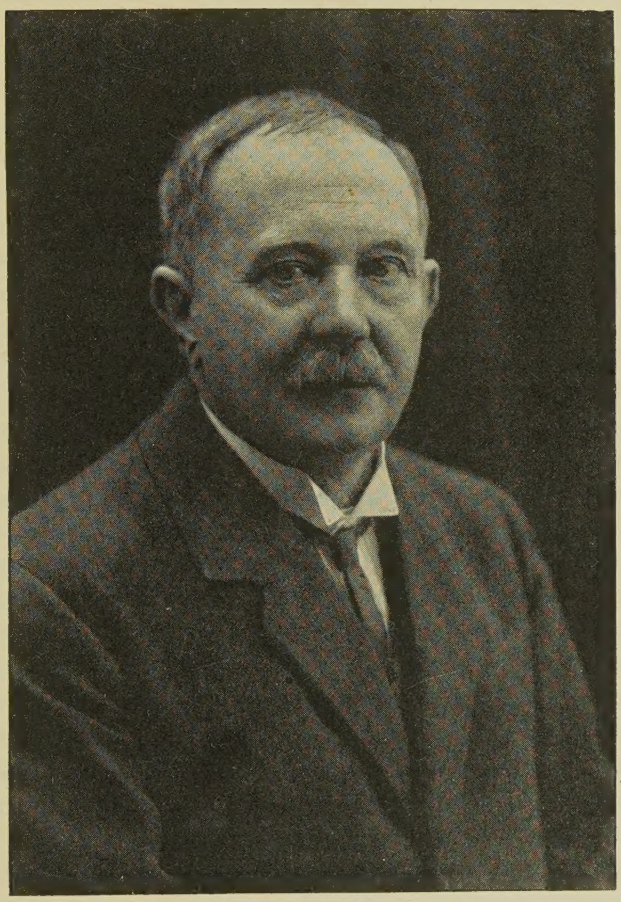

A. C. Johansen.
(1867–1931).

Death has made frequent inroads within the International Council for the Exploration of the Sea. This Council is reaching an advanced age and one by one its older members and trusty workers are going hence. Dr. A. C. Johansen, however, could not at his death be reckoned as one of the aged. He had not completed his 64th year. A protracted illness had prematurely

injured his health and he died on the 13th May 1931, after an operation for an abdominal ulcer.

His death interrupted a devoted labour of thirty years in the service of scientific fishery investigations. In 1902 he was appointed assistant to Dr. C. G. Joh. Petersen at the Danish Biological Station and in 1903 assistant at the Danish branch of the International Exploration of the Sea. In 1909 he became a member of the Danish Commission for the Exploration of the Sea and was put in charge of its fishery investigations in the waters around Denmark. Finally, in 1926, he succeeded Dr. Petersen as director of the Danish Biological Station.

During his long career of research Johansen published a great series of important papers. As the plaice is the most important species of the Danish fisheries it was natural that he devoted himself chiefly to this fish. In a series of papers entitled: "Contributions to the Biology of the Plaice with special regard to the Danish plaice fishery" he presented the results of his investigations. Herein he was able *inter alia* to prove conclusively that plaice are indigenous to the Baltic and not, as was previously believed, recruited by migrations from the Cattegat. This, as he maintained, was of great importance as it became a question of measures being taken for the protection of plaice in the Baltic and Cattegat. Besides he devoted a great deal of labour to the study of the races of the plaice and during the course of several years he carried out investigations on a large scale regarding the occurrence of the young stages of the plaice on the coasts of Denmark whereby he could observe the variations in the recruiting of the plaice population.

Furthermore Johansen made investigations regarding the turbot and common sole as well as the mackerel and eel.

Later on he applied himself with ardent zeal to investigations regarding the herring. Here he accomplished exemplary work concerning the races of the herring. In several papers he has dealt with these races in the large sea areas of north-western Europe and also in the Skager Rack and Cattegat. He also instituted, while co-operating with Germany and Sweden, annual investigations of the abundance of herring larvae in the Cattegat and southern Baltic, to be able, at an early stage, to observe the fluctuations in the year classes of the herring.

JOHANSEN'S spirit of research urged him even to take up very difficult but fundamentally important questions. Thus he has published works on the cause of the fluctuations in the quantity of fry among plaice and on the cause of the changes in salmon and eels.

JOHANSEN'S treatises have, for the most part, been published in "Meddelelser fra Kommissionen for Havundersøgelser", in "Rapports et Procès-Verbaux" and in "Wissenschaftliche Meeresuntersuchungen".

It is quite evident that I am only able briefly to intimate the great work accomplished by JOHANSEN. But what I have stated ought to have shown how immensely comprehensive and important his research work has been. His researches are remarkable for their thoroughness and scientific acumen. In this connection I should like to say that his investigations of the herring are the acme of his researches.

In all his scientific work his constant idea was that his researches should lead to practical results for the fishery. He had devoted his life to fishery investigation and the advancement of the fishery was always the object of his labours. When he found that it was scientifically demonstrated that the fishery was too intense in respect of one species of fish or that the stock was not being fished economically he consequently considered that measures should be taken to protect the fish. It was therefore a great disappointment to him that the plaice was not internationally protected in the North Sea. He contributed greatly to plaice in the Baltic being protected by an international convention and he also worked hard to procure better protection for plaice in the Cattegat and Skager Rack. He was not, however, destined to complete this work.

As a proof of his zeal directly to benefit the fishery may be mentioned his extensive transplantations of plaice from the west coast of Jutland to the inner waters of Denmark and his scheme for the transplantation of plaice to the Dogger Bank.

He was also interested to a high degree in fishery forecasts and in this connection may be mentioned his work on the eel and mackerel.

He also laid great weight on the fishing population getting a knowledge of the results of the investigations. This is vouched for

by his numerous articles in "Dansk Fiskeritidende" and in "Skrifter udgivne af Kommissionen for Havundersøgelser".

JOHANSEN was originally greatly interested in the mollusc fauna of Denmark. The thesis for his degree, Dr. phil., was on the fossil quaternary mollusc fauna of Denmark, and he never lost his interest in this group of animals. Instances of this are to be seen in his great works on the changes in the fauna of the Ringkøbing fjords (1913) and the natural history of the Randers fjord (1918). To the very last he was engaged on a new publication on the Ringkøbing fjord and had a large supply of material for a work on the distribution of the Danish molluscs.

JOHANSEN's research work, therefore, embraced a large sphere of action. In the domain of fishery biology he was certainly one of the most prominent of his contemporaries. It was obvious that a man of his capacity should be required by the International Exploration of the Sea. Ever since 1909 he took part as an expert in the proceedings and work of the International Council for the Exploration of the Sea. When the Council appointed Committees for different areas, JOHANSEN was, as a matter of course, appointed chairman of the Transition Area Committee.

He had great qualifications which could make an important contribution in the international work. His vast erudition, his profundity and critical mind were here of the greatest service to him. His speeches at the Council or at the deliberations of the different Committees were, therefore, always gladly and respectfully listened to. The work he did in the International Exploration of the Sea was invaluable. Here he was untiring and he retained his interest in biological research to the very last.

JOHANSEN was of a retiring, unpretentious nature. His was a sterling, noble personality entirely devoid of vanity. He was a good and trusty friend and possessed many friends. He leaves a great void behind him.

K. A. ANDERSSON.

The Oyster Industry in North America: a record of a brief tour of some of the centres on the Atlantic and Pacific coasts, and of a summer in Canada.

By

H. P. Sherwood, B. A.

Fisheries Experiment Station, Conway, N. Wales.

Introduction.

During 1930 it was the writer's good fortune not only to spend the summer months in Canada working on oyster investigations in Malpeque Bay, Prince Edward Island, but also, before returning to England, to visit some of the oyster raising areas on both coasts of the United States for the English Ministry of Agriculture and Fisheries. But for the interest aroused in England by reports of remarkable new methods applied to oyster culture in the State of Washington, there would have been little prospect of making the unforgettable journey across the continent from Prince Edward Island along the St. Lawrence, past Lake Superior, through the prairies and the Rockies to Vancouver Island, and back from Seattle by Chicago to the coast at New York; a round of 9,000 miles, occupying three weeks full of intense interest, particularly to a visitor from Europe.

In this article the writer has attempted to present a very brief outline of the oyster industry in North America, which is of remarkable interest and magnitude, and of investigations in Prince Edward Island, together with a series of more detailed pictures of oyster culture in the centres he was able to visit, to which the outline will serve as a background. Sufficient narrative has been included to connect descriptions of the various places visited.

Visit to Halifax.

As Canadians agree, it is unfortunate that during the winter closing of the St. Lawrence, travellers and immigrants receive their first im-

pressions of the country from this port; for although the attractive scenery of the North-West Arm is close at hand, the town itself in early April is hardly looking its best.

The Fisheries Experiment Station at Halifax — one of the Biological Board's five marine stations — is now housed in permanent quarters, another building beside the old adapted wooden structure having recently been completed. It is conveniently placed near the quays, but the surroundings can hardly be described as attractive. An outstanding achievement of this station is the production of frozen fish of a superior quality in the form of "Ice Fillets"; small half pound blocks of fish 5 by 3 by 1 in. wrapped in waxed paper and frozen solid in twenty minutes, while separated from direct contact with the freezing brine by a thin sheet of metal. In addition to the rapid freezing of the fillets, importance is attached to cooling of the fish when storage is necessary between catching and filleting. It is brought down to just below freezing point by immersion in brine of slightly lower salinity than sea water. Several kinds of fish are used for these fillets; haddock, cod, flounder, salmon and others. Uniformity of temperature in the cold store is important too, that is, both the avoidance of fluctuations, and also of the presence in the store of exposed pipes colder than the surroundings, on which condensation occurs, followed by drying of the stored packets. An inner lining to the store helps to provide the desired uniformity. The joint output of ice fillets from this station and that at St. Andrew's, N. B., amounted last year to over 50 tons. Work is continuing on the further elimination by machinery of hand labour during preparation, which at present keeps the price slightly above that of fresh fish, and restricts output and marketing. A trial of the product specially cooked in a hotel convinced the writer of its quality and convenience.

The journey to Prince Edward Island was made at the end of a week spent at Halifax, which left pleasant recollections of the contact with the director (Dr. Leim) and the staff of the Experiment Station.

Oyster Culture and Investigations in Malpeque Bay, P. E. I.

This bay is a much indented and nearly closed inlet from the Gulf of St. Lawrence, having an area estimated at about 40,000 acres, of which perhaps 10,000 acres might serve as oyster bottoms. Very little of it exceeds six metres in depth, in fact about half of it is not more than four metres. The maximum tidal rise and fall is not much over 1 metre. Salinities vary from between 27 and 29 per mille near the heads of the numerous "rivers" or creeks, to 29 or 30 per mille near the open gulf.

Summer temperatures may remain over 20° C. for several weeks in the "rivers".

At one time the bay contained a valuable oyster fishery providing occupation during the season for five or six hundred persons. The annual production about 1890 amounted to 30,000 barrels. Then it declined and came to an end in 1917, owing partly to administrative difficulties in the past which prevented timely enforcement of adequate measures for conservation, and partly to a disastrous mortality in 1915 and 1916,

Fig. 1. View from the head of one of the creeks of the Bideford river, Malpeque Bay, at low water, showing eastern oysters (*Ostrea virginica*) attached to boulders exposed at low water. On this occasion the water in the foreground was quite fresh. Throughout the winter the creek together with the whole bay is frozen over.

which frustrated the efforts of the dozen or so companies to which belated leases were granted in 1913 for the purpose of re-establishing the fishery. These companies had endeavoured to restock their beds with oysters imported from the United States. During the winters the beds were formerly exploited for shells as a source of lime, with the aid of mud diggers, grabs supported by cumbersome frameworks, worked through holes in the ice by horses, producing extensive "mud cuts" on the beds. This practice of spreading on the fields the mud containing shells so obtained was discontinued some years ago. It was said to render potato crops liable to disease. Remains of mud diggers are still a common sight.

In 1928 the Dominion Government by agreement with the Provincial Government undertook control of the oyster fishery in this area, together

with the problem of resuscitating the beds. Recommendations based on scientific investigation were not lacking. Joseph Stafford and Julius Nelson, pioneers in oyster research, had both worked there. In 1928 and 1929 the services of an oyster farmer from the United States were obtained to make a start on cultivation work. Scientific work was begun in 1929 for the Biological Board by Dr. Needler, who in 1930 took over also direction of the cultivation work. The Bideford "river" was selected as the most promising centre for research and for a demonstration of the measures needed to restore the productivity of the area. A new oyster boat was equipped and manned. Plans were made for the building of a Marine Station at the head of the Bideford creek for the 1930 investigations, but owing to unavoidable delays it was not ready till the end of August, and work continued in temporary quarters.

Briefly, the cultivation work has resulted in the cleaning of bottoms and the formation of two or three beds on which all the oysters in the creek have been concentrated as far as possible; the catching and planting out in 1929 and 1930 of what in the circumstances were satisfactory sets of spat on shell cultch in wire netting bags, and the destruction of large numbers of starfish, removed by trailing mops of cotton waste on the beds. The scientific work in 1930 included recording of temperature, salinity, p_H, and tidal amplitude; investigation of spawning and sex change in the oyster, of the distribution of larvae and spat, of the value of collectors of different types, and of the best time and places for planting spat. A trial was also made of the value of small wooden tanks or enclosures on the shore for investigating various factors under controlled conditions.

Visit to St. Andrew's Biological Station.

In August, an opportunity was taken for a week-end visit by road to the Biological Board's Marine Station at St. Andrew's, New Brunswick. This station is most attractively placed on a steep spruce-covered portion of the rocky shore bordering the bay. It is essentially a summer station, conveniently planned with bungalow or hostel residences for staff, vacation workers and others. Though primarily a marine station, fresh water investigations are falling increasingly within the scope of its work. Recently added to the normal equipment of any such station is a building containing a cold storage plant and the wherewithal, as at Halifax, for production of ice fillets of fish. There are also water storage and hatchery tanks, and tanks with circulating sea water placed in a dark cool cellar to avoid any rise of temperature above that of the inlet, which remains in summer at much the same temperature as the Bay

of Fundy, namely about 10° C., so that in consequence fogs are prevalent. This is accounted for by the great depth of the inlet, which is such that anchors are not usually carried in the small rowing boats used by the station. The fauna of comparatively deep water is therefore close at hand. Investigations planned or in progress, under the energetic directorship of Professor HUNTSMAN, include the following:— a study of conditions in a series of tidal pools in which the water level can be controlled by a dam; the effect on the chemistry, flora and fish population of a fresh water lake a few miles inland, which was being "manured" by the dumping of a ton or so of mussels (*Mytilus edulis*); recording of the cycle of changes in water stored in exposed tanks, and experimental feeding of trout. As already indicated, low temperature research is to the fore, especially the mechanical preparation of ice fillets.

Brief Outline of the Oyster Industry in N. America.

The total production of the oyster beds in the United States is enormous, constituting the most valuable fishery of the country. Recent figures put the annual yield at about 73,000 tons of food, valued at over $14,000,000. The number of oysters marketed annually cannot be far short of 6,000,000,000, and over 63,000 persons are employed. There are large companies owning as many as forty steam or oil driven oyster boats, having dredging rights over areas in several States. Some companies are concerned mainly with production of seed oysters to be sold for planting elsewhere, others purchase seed oysters and grow them to marketable size, while others again raise and market their own seed oysters, but supplement them from other sources. There are smaller companies and individual owners of oyster schooners with auxiliary motors, and lastly oystermen who have no dredging boat, but fish in shallow reserved portions of public beds, using a pair of long handled tongs fitted with rake-like jaws. The industry, like others, has not escaped the attention of "racketeers" in the larger cities.

Cultivation consists of providing in the summer spawning season clean shell cultch on the beds for attachment of the oyster larvae, culling, or separating and sorting oysters from clusters on the cultch, planting of spat and half grown oysters, together with measures for destroying pests, and is carried out on leased beds in the northern States, where only by careful conservation have the beds been saved from threatened extinction.

The demand for oysters is very great, and compared with prices in Europe they are cheap. Regularly, perhaps once or twice a week, some

dish containing cooked oysters forms the main item of a meal in many city households, and there is an enormous sale of oysters which have been "shucked", or removed from their shells, then washed and packed in cans of various sizes, ice-cooled for distribution. The widespread use of refrigerators ensures the product remaining fresh for several days. The shucking of oysters employs large numbers in the "opening houses"; and, what is of great value to the industry, retains the shells for return to the beds as cultch.

On the Atlantic coast natural beds of *Ostrea virginica* at one time formed reefs at the mouths of most of the rivers from Maine to Mexico. The wave-washed shells on such reefs offer clean places for attachment of larvae. It may be mentioned in passing that recent work in New Jersey on the movements and distribution of oyster larvae has resulted in an interesting explanation of the occurrence of oyster beds in estuaries. Owing to ruthless exploitation in these reefs, not only for food, but also for road building and as a source of lime, no oysters are now found north of Cape Cod, except for a few small fisheries in sheltered inlets on the Canadian coast. Among remedies for an excess of fishing over natural production are, of course, return of shells to the beds, enforcement of a close season, and a size limit. Lawlessness on the part of oystermen in the past has rendered most difficult the work of conservation when attempted by the States. There are now in some centres oystermens' associations, the increasing influence of which helps to maintain observance of regulations. Restoration of the beds in Connecticut and New York became hopeless, and they passed into private ownerships. Further south, in New Jersey and Delaware, the natural beds are used for seed production. Under State control they are open for a few weeks in each year, and some are cultched by co-operation between the State and the oystermen. Oysters are raised for market on the adjacent leased beds. Further south again, in Maryland, Virginia and the other southern States, the natural beds are the chief source of marketable oysters. These beds are open except during the summer, and minimum size laws are enforced. Practically no planting is done, the temperature conditions being favourable to abundant reproduction; but oysters in the south lack the qualities of those in northern waters.

In the southern States, oysters grow in dense clusters, and on account of rapid upward growth, which keeps them out of the mud, they are long and narrow. Such oysters are known as "coon" oysters. On the reefs they may be attached one above the other in a pillar-like structure. Below low water line, practically no young oysters are found, possibly on account of ravages by whelk drills or other pests. The opening

of oysters in these clusters is difficult, and in places it is the practice to steam them open. In any case many small oysters are wasted. Steaming has been noticed to produce a slightly rancid flavour at certain times, from the effect, it is said, on the oily constituents of the plant food (Dinoflagellates) contained in their stomachs. Climatic conditions and the distribution of the population make the problem of transport difficult and restrict marketing in the south, and it is evidently not feasible to replenish beds in the north from this source, possibly also from inability of the southern oyster to stand colder conditions.

During the winter in the northern States, coldness of the water reduces ciliary activity of the oyster to a very low level, a condition to which the term hibernation is applied, and which has a bearing on the sanitary control exercised by State and Federal authorities. Many formerly profitable growing grounds have been closed by reason of sewage and industrial pollution. Grounds are inspected and classed as free from pollution, doubtful, and badly polluted. Marketing from the last mentioned is prohibited. From the intermediate class it is licenced only under special conditions. Experiments in the treatment of oysters from these beds have been in progress for some years.

On the Pacific coast natural beds have been exhausted, and the industry is practically confined to inlets in the State of Washington. Production in British Columbia to the north, and in Oregon and California to the south is relatively insignificant. The total production of the States on this coast is under one per cent of that for the whole of the States. Conditions and methods differ strikingly from those on the other coast, not only from climatic causes, but due to specific requirements of the native oyster.

Since 1881, when Ingersoll's detailed and comprehensive work on the oyster industry of America was published, more recent information relative to the Atlantic coast, apart from statistics, has become available only in separate papers dealing with conditions and investigations in particular States or localities. An account of oyster culture on the Pacific coast by Dr. Galtsoff appeared in 1929.

Research and surveys are carried out by the Federal Bureau of Fisheries and by State or private experiment stations with university co-operation, and also for the influential association of oyster growers and planters of N. America by the Pease Laboratories in New York. Following a decline in the industry, which since 1906 has reduced the production of oysters to two thirds of the former quantity, there is a demand for a greatly increased supply of seed oysters in many of the northern oyster growing areas, although natural spat falls may in some

seasons be very prolific. A few years ago this stimulated renewed interest in the problems of raising spat artificially, but more recently research has been directed to extending the possibilities of securing good sets of natural spat, and to destroying pests, rather than to developing hatchery methods. Thus, for example, otherwise unproductive muddy tidal flats may be turned into valuable spat catching ground by the use of shell cultch not scattered broadcast, as is the practice on hard bottoms, but piled up in wire netting bags or crates at a level ascertained by previous trials. In a few sheltered localities cardboard partition collectors dipped in cement mortar have been successful, but in others they have been destroyed by wave action. It remains to be seen to what extent the commercial application of new methods will help the industry.

Visit to the Pacific Coast.

Proposals for a tour which would include the Pacific coast received the English Department's approval. Conditions in the southern States, however interesting, differ considerably from those in Europe, on account of consistently more favourable temperatures and the presence of natural oyster reefs. In any case, limitation of time available prevented the inclusion of southern States in the tour. A break in the writer's services with the Biological Board was kindly agreed to by Dr. Huntsman. This arrangement enabled a start to be made in September instead of in October, thereby making it possible to take advantage of summer travel facilities, and also what was more important, to see certain oyster beds which on subsequent spring tides were uncovered only during darkness.

The tour had to be planned without the assistance of Dr. Galtsoff (in charge of oyster fishery investigations, U. S. Bureau of Fisheries), who was away for the summer, and with whom unfortunately no meeting was possible later. An invitation to visit New Jersey, and to see something of the industry in Delaware Bay, had been received from Professor Thurlow Nelson of Rutgers University, New Brunswick, N. J., with whom the writer had been in correspondence for some years. As a week-end late in the tour best suited him, a decision was made to visit the Pacific coast first.

The journey from Prince Edward Island to Vancouver, a distance of nearly 3,700 miles, lasted five days and nights from early on Saturday Sept. 13th till early on Thursday Sept. 18th. The Sunday was spent in awaiting the departure from Montreal of the trans-continental express.

Mr. C. R. Elsey from the Biological Board's Station at Nanaimo,

was still at his field station with the Crescent Oyster Co. on Boundary Bay near Vancouver, a few miles north of the international line. This was the first point to be visited. It was reached in the early afternoon by a thirty mile motor coach journey to a point on the coast south of it by some six miles, which were covered in a north-bound train. Crescent is an attractive small summer resort, but is poorly served by the railway, and lies off the motor coach routes. The afternoon was profitably spent in discussion, and early next morning advantage was taken of the spring tides to see as much as possible of the beds.

It is desirable at this point to make a brief survey of conditions at

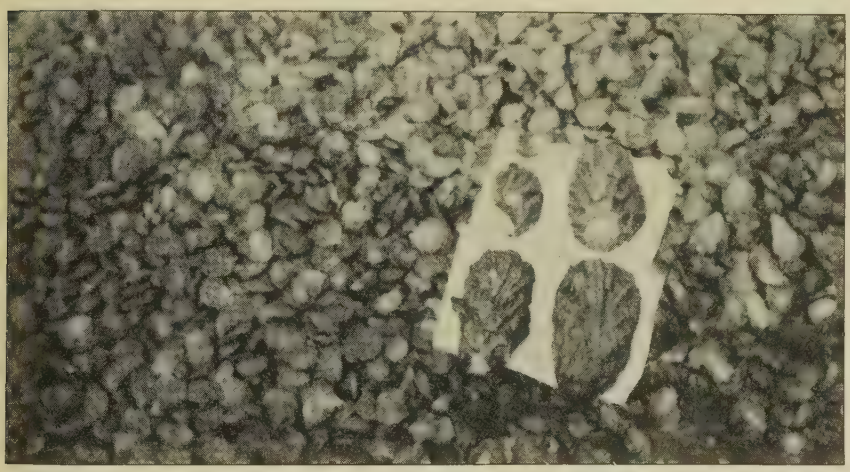

Fig. 2. A heap of culled Pacific native oysters (*Ostrea lurida*), with four Japanese oysters (*Ostrea gigas*) for comparison. The largest of these is 20 cm. in length.

Crescent, which are of special interest on account of the presence of oysters from three widely separated sources, and also because of the possibilities of future development. First, however, a few details of the biology of oysters to be found on the Pacific coast will serve as an introduction not only to the Crescent beds, but to other points visited, namely, Oyster Bay near Olympia, and Ladysmith (Vancouver Island), as well as Willapa Bay, which though not visited will be referred to later. These oysters are:—

Ostrea lurida ..... The native
— *virginica*..... Transported from the Eastern States.
— *gigas* ..... Imported from Japan.

The native oyster is not unlike the European flat oyster (*O. edulis*) but it grows slowly and seldom exceeds about 5 cm. across when marketed

at four or five years old. Like *edulis*, after spawning it retains the embryos within the mantle cavity, having then the same "white-sick" or "black-sick" appearance when opened. The shell has a slightly pigmented muscle scar. On account of its small size it is retailed "shucked", i. e. removed from the shell, and packed in tins for cooking purposes. The eastern oyster, a familiar example of which is the Blue Point as shipped to Europe, is retailed in America both shucked and on the half shell. This applies to the Japanese oyster also. The shells of these two are distinguished by the presence of prominent ridges in the Japanese species, which also lacks the purple pigment so conspicuous in the muscle scar of the eastern. Both may reach several inches in length. When crowded on natural reefs, the eastern oyster may grow to be remarkably long and narrow.

Under the same temperature conditions, spawning occurs in the following order, with some overlapping:— native, Japanese, eastern. Though the larvae have a general resemblance in pigmentation, and at certain stages in general outline, the later stages at any rate can be distinguished. Larvae of the native bear a close resemblance in size and shape to those of *Ostrea edulis*. The prominent left umbo distinguishes the eastern, while the Japanese larva has an umbo similar in shape to that of the eastern, but less prominent. Mr. Elsey is able to distinguish between eastern and native spat by measuring the original larval portion of the shell: the native is 0.25 mm. across, the eastern 0.30 mm.

Oyster Culture at Crescent, B. C.

The Native Oyster. The use of shallow enclosures is characteristic of the culture of this species. The reason for this appears to be as follows:—

The oyster is found in muddy estuaries and inlets where oyster dredges cannot be used both on account of the soft nature of the bottoms, and the small size of the oyster; a size which also renders the use of tongs in the ordinary way impracticable. Tonging is, of course, practised to a considerable extent on the Atlantic coast with the much larger eastern oyster. The oysters therefore have to be accessible at low spring tides, when they are raked and forked or shovelled by hand. Beds are prepared near ordinary low water level by spreading gravel and shells to render the bottom capable of supporting the weight of a man. The wearing of special mud shoes may be desirable on some beds. As the native oyster is susceptible to extremes of temperature which the eastern and Japanese oyster can withstand, these special bottoms are provided

with low dykes of concrete or creosoted timber retaining a depth of about 18 ins. of water over them at low tide.

The preparation of these beds represents a considerable investment. Levelling the ground and building the dykes costs from one to three thousand dollars per acre. At Crescent there are about 6,000 acres available for dyking and 2,000 acres of natural ground. The ground is leased at one dollar per acre for a period of 21 years. Spat is caught in the summer by spreading oyster shells in the dyked areas. Some of the beds are two or three miles out, and in winter are exposed only during darkness. They are fished once a month and the supply of oysters is kept in "floats"

Fig. 3. A Sikh culling native oysters at Crescent, B. C., on the Oyster Company's stage. Behind the boxes on the right is the slatted end of one of the storage floats.

alongside the culling and packing house. They are culled to remove shells and immature oysters, and sorted. A point of interest is the employment there of Sikhs from the Punjab. They are paid at the rate of 40 cents an hour. As an example of yield from one of the dyked enclosures, the following figures obtained from the manager are of interest:— one year (1929) an enclosure 300 yards by 50 yards (about 3 acres) produced 750 sacks weighing about 125 pounds (56 Kgms.) containing 4 to 5 thousand oysters each, valued at 12.50 dollars per sack. That is, a yield per acre (about 0.4 hectares) of between 1 and $1\frac{1}{4}$ million oysters, worth somewhat over three thousand dollars. This wholesale price works out at about 100 oysters for 30 cents. It has to be remembered that this production is only every second or third year for any one enclosure. As mentioned above, they are sold "shucked", fetching a retail price in restaurants of 90 cents a pint, or about $\$1\frac{1}{2}$ per litre.

A similar but more extensive and elaborate system of enclosures has developed in the southern portion of Puget Sound, at Oyster Bay near Olympia, which is regarded as the centre of the native oyster industry. Elsewhere, at Ladysmith on Vancouver Island further north, dyked enclosures have not been constructed. The Crescent beds are thus intermediate in development between those of Olympia and Ladysmith.

The Eastern Oyster. In May, consignments are procured from New Haven (Long Island Sound) and relaid at Crescent, after their second winter. Seed transferred after one winter does not thrive. Dyked enclosures are considered unnecessary and even undesirable. The oysters on arrival are spread on ground where eel grass grows and which is uncovered at about half tide. They are marketed the following winter after one summer on these beds during which the mortality averages 10 to 20 per cent. It is unprofitable to keep these oysters for another winter, for the mortality among those left unsold reaches 80 or 90 per cent. They are sold both in the shell and shucked, fetching respectively 35 c. a dozen and $3.60 a gallon[1]) of about 160. The retail price for oysters on the half shell is 40 or 50 c. a dozen.

It is interesting to note that as a result of the importation of the eastern oyster, the eastern drill (*Urosalpinx cinereus*) is very common at Crescent.

The eastern oyster does not normally reproduce at Crescent, but recently spat has been discovered in the tidal portion of adjacent rivers (the Serpentine and Nikomeki) just below the sluice gates, where collectors were placed in 1930. Spawning was over by July 20th according to Mr. Elsey's observations. By mid-September some of the spat had reached 3.5 cm. across, and none was under 1 cm. This local eastern spat is not subject to the serious mortality which attacks imported seed, a point of importance suggesting the possibility of raising eastern oysters and ultimate independence of supplies brought from the Atlantic.

The Japanese Oyster is grown for market from seed oysters imported in March from the north of Japan. On arrival they average about 1 cm. across, being of the previous season's set. Planting is done on ground similar to that suitable for the eastern oyster. Dyked enclosures are not necessary. The spat is, of course, still attached to collectors, and for some time "Abalone" (*Haliotis*) and other shells have been used in preference to bamboo shoots, to catch spat for export to America. The shells are packed in boxes of four cubic feet capacity, and shipped

[1]) The U. S. gallon of 231 cubic inches.

as deck cargo on passenger steamers. Each box contains from five to ten thousand spat. Mortality in transit, which involves a period of about a fortnight out of water, does not exceed one per cent, and further loss up to the time of marketing during the second winter after planting, does not as a rule reach 5 per cent. The clusters of spat grow rapidly from 1 cm. to 8 or 10 cm. during the first summer after planting. The oysters are sold largely shucked, in which case the clusters are not broken up into individual oysters.

[1]) On Sept. 19th a very early visit was made by road to the sluice gates on one of the rivers near Crescent. The spat there derived from eastern oysters was about the size of that seen a fortnight later in Long Island Sound. As the river was very muddy, the collectors had been secured above the bottom by attachment to the piles lining the bank below the gates. During a visit made later in the morning to the nearest beds of native, eastern, and Japanese oysters, the repair and raising of one of the dykes was in progress, together with the clearing up of oysters which had been washed out of the enclosure. Starfish, slipper limpets (*Crepidula*) and crabs are not regarded as serious pests, but trouble arises from a decapod crustacean the "crawfish" (*Upogebia pugetensis*), when one limb of its Y-shaped burrows passes under a dyke, which allows water to escape. Whelk drills are a menace, and both the Japanese drill (*Tritonalia*) and the eastern *Urosalpinx* are present. Spat could be found already drilled at a size of only 2 or 3 mm. across. The native spat which had survived was roughly 1 cm. across.

That morning the beds were visited also by representatives of the "B. C. Packers", the largest firm of fish packers on the coast, who had applied for leases for over 3,000 acres at Crescent as part of a scheme for development of oyster fisheries in all the suitable inlets up to the Alaska coast. A large company such as this has a steamer service and labour available at off times for other work, so that it would be able to ship shells very cheaply for cultch as ballast in steamers returning from the north. During the next few years therefore, considerable expansion of the industry on this coast may be anticipated, if the investigations now being made show promise.

Having spent the afternoon in the laboratory, I took the evening train from White Rock, whither Mr. Elsey kindly motored me, for Seattle, and arrived there at 10.30 p.m.

An interesting morning (Saturday Sept. 20th) was spent in the new

[1]) From this point the record of the tour assumes more the features of a diary, and will therefore be continued in the first person to avoid wearisome repetition of such phrases as "the writer and his companion".

Department of Zoology at the University with Professor Trevor Kincaid, who had very kindly postponed an engagement in order to be at my disposal for the week-end. My visit fell during the reorganisation of his department in its new building in readiness for the forthcoming term. The professor, though by no means an old man, has been head of the department for some thirty years. It should be explained that his name had been coupled with the reports of remarkable new methods applied to oyster culture in Washington, reference to which was made in the introduction to this account. A native of Olympia, the State Capital of Washington (at the southern extremity of Puget Sound, and the centre of the oyster industry in the Sound), he has long been interested in oyster culture problems, and it appears that he was largely instrumental in the introduction of the Japanese oyster to this coast. His services as scientific director to new commercial oyster companies operating in Willapa Bay are an asset which they fully recognise, and at the time of my visit, a few weeks before the opening of the new Willapa beds, his work and opinions, together with the virtues of the new oysters, were being brought before the public by the press, a state of affairs not easily reconciled with his modest outlook. Similar publicity doubtless accompanied the formation of one of the companies a year or so previously, and reports reaching Europe probably stimulated the interest to which the tour now being described is largely due.

On the Saturday afternoon Prof. Kincaid took me in his car to Olympia. Here we remained for the night, and sampled the local oysters. A "pan roast" of Olympia oysters partaken of at a noted restaurant unfortunately failed to do them justice; they were partly embedded in extremely sloppy toast and smothered in peppery tomato sauce. The following morning an early start was made for Oyster Bay, some fifteen miles further on, making a total distance of 75 miles from Seattle. With the Manager (Mr. Waldrip) we visited the Olympia Oyster Company's beds. It appears that the system of dyking at Olympia had been initiated by his father. While the industry at Olympia has been maintained by careful cultivation during the last thirty years, that at Willapa Bay declined and has remained negligible since 1915. The whole output from this coast in any case is less than 1 % of the total for the United States, though the value of the annual yield is nearly 3 %. Having seen the beds which are described below we returned to Olympia in the early afternoon, followed by Mr. Waldrip, who very kindly came specially to show us round the Company's opening and packing house and office premises, which were closed for the weekly holiday. We then returned to Seattle.

The following day, Monday Sept. 22nd, I spent the morning with Prof. KINCAID at the University, and learnt what I could of the oyster culture activities with which he has been particularly concerned during the last few years. During the afternoon I accompanied him to the business quarter of Seattle to meet and lunch with the president of the Willapa Oyster Companies, and to see a special and most interesting "movietone" demonstration given by the Western Electric Co. with a

Fig. 4. Dyked enclosures in Oyster Bay, Olympia, and floating culling houses.

view to inducing the Oyster Companies to have their advertising film converted into a "movietone" for use with a portable sound film outfit. Circumstances prevented Prof. KINCAID from taking me to the Willapa area, which is quite another sixty miles beyond Olympia. The information about it which he kindly supplied will follow an account of oyster culture at Olympia.

Oyster Culture in Oyster Bay, Olympia.

The outstanding feature here is the extensive development of dyked enclosures. Most of the dykes are of concrete, about ten inches wide, running eighteen inches or so above the ground level. Great importance was attached to selection and preparation of the sites for these enclosures, which had to be levelled and spread with gravel. Adjacent enclosures on what were originally sloping bottoms, form a series of

terraces. Construction of enclosures here may cost between $ 2,000 and $3,500 per acre.

Special mud shoes are worn for working in them. As regards pests, slipper limpets — two species of them — and small crabs are not regarded as troublesome, nor do starfish invade the enclosures. Drills do considerable damage, and as at Crescent the crawfish give trouble when their burrows pass under the dykes. Ducks of various species inflict much loss by feeding on the oysters.

The winter is occupied mainly with the marketing of full grown oysters. They are raked together at low tide, loaded by means of special forks on to small rafts or "scows", and taken to the culling houses situated near or even on the beds, where they are sorted by hand and bagged ready for delivery by launches to the opening and shipping houses. Under-sized oysters are returned to the beds. From March to June spat from the previous year is moved to growing and later to fattening areas from enclosures in which oysters do not fatten well. When cleared, these enclosures are again cultched with shells of native oysters for the summer set of spat, which occurs in July or August. Three year old oysters planted in the spring in fattening enclosures are left over the next winter and marketed the following autumn. Thus they remain for two summers in the same enclosures to fatten. The enclosures are said to vary from time to time in their spat catching and fattening propensities.

The following was given as the yield of matured oysters from one of the Company's enclosures:— 365 sacks of about 4,000 oysters each from $^3/_4$ of an acre, equivalent to nearly two million per acre, or about 400 oysters per square yard. This production is not, of course, annual. Owing to the recurrence of three bad spatting seasons, and to a severe mortality following the coldest winter for fifty years, prices had been advanced from $13 to $20 for a sack of two bushels weighing about 100 pounds, and containing about 4,000 oysters. The opened oysters are sold at $7.50 per gallon ($2 per litre).

Labour on the Olympia beds is supplied almost entirely by Japanese families, which have their living and working quarters in the floating culling houses moored not far from the enclosures. Under supervision of the State Health Service, special precautions are taken by means of chemical treatment and collection of sewage and refuse to prevent contamination of the beds from these house-boats. This arrangement appears feasible only where relatively small quantities of material have to be dealt with, and where the parties concerned are directly interested in preservation of the beds from pollution. As a rule house-boat and

equipment are provided, and the occupant finds the furniture and an outboard motor engine. He receives $2.50 for each sack of oysters culled. Two workers may get six or seven sacks a day, the number depending on the ground worked.

As already mentioned, the sacks of culled oysters are collected by launches and taken to one of the opening and despatching houses in Olympia. That of the Olympia Oyster Company is a model establishment, and the scrupulous cleanliness of the whole place greatly impresses a visitor. Work benches, walls and floors are surfaced with smooth cement. Containers for oysters in the opening room and in the cold room are of Monel metal. The comfort and efficiency of the openers is considered by the provision of good lighting, adequate warmth and ventilation. There is even a hot water pipe for keeping their feet warm. Such is the skill of the Japanese — both men and women — that the best workers can shuck about one thousand oysters per hour. One gallon contains between 1,600 and 2,000 shucked oysters. Smaller quantities also down to one half pint are packed uncooked in sterilised cans, which are hermetically sealed, labelled, and placed with ice around them in wooden boxes ready for distribution. Such oysters if kept chilled on arrival are said to keep in first rate condition for ten or more days after despatch. The shells are returned to the beds for use as cultch, and are supplemented for that purpose by others purchased elsewhere for 35 to 50 cents per bag. A small proportion of the oysters contain pea crabs (*Pinnotheres* sp.), which are saved from the opening houses and sold for soup.

Oyster Culture in Willapa Bay.

The importation of Japanese oysters began about thirty years ago with small consignments of seed planted in Puget Sound. Though these are regarded as inferior in quality to the native and eastern species, the quantity imported has steadily increased, and from 1,000 to 4,000 boxes of seed oysters, containing about 10,000 spat each, are planted annually in Samish Bay. Prof. Kincaid has been closely concerned in the recent planting of Japanese oysters on areas in Willapa Bay, an inlet on the open coast some 60 miles S. W. of Olympia, which formerly contained extensive natural beds of native oysters. Indiscriminate fishing of these beds was begun about 1850, and the production of oysters in this area soon fell and dwindled away until 1915, by which time the beds were practically exhausted. Following preliminary plantings of Japanese oysters, which showed that growth was remarkably rapid, companies were formed and carried out extensive plantings in 1928 and subsequent

years. For the first marketing season beginning in October 1930, it was anticipated the yield would be 30,000 gallons, or between three and a half million and six million oysters, there being when packed from 120 to 200 shucked oysters per gallon. The wholesale price was to be $3.50 per gallon (or 1 litre for 90 cents).

The beds are planted by laying fifty boxes of spat per acre. The boxes are of four cubic feet capacity and contain each about 10,000 spat attached to oyster, scallop, and abalone shells. The cost per box is $6, with $1 for laying and 75 cents for shipping, making a total of $390 per acre. Mortality among the spat is small, and the margin of profit to be made by importing the seed in March and marketing the oysters which are ready in September of the following year (that is, after eighteen months) is considerable. Experiments have indicated the best level for planting to be that of average low tides.

The possibility of these planted oysters reproducing and restocking the beds is naturally of importance to the industry. Prof. KINCAID, who has experimented for some time in tanks at Samish and Willapa Bay with this end in view, regards the Willapa area as most promising for the following reasons: — this inlet is situated at the confluence of four or five rivers, none of which is glacial (as are most of those flowing into Puget Sound) and whose tributaries drain rich alluvial country and supply the essential elements for an abundant growth of diatoms, etc. In the summer the long estuaries warm up to 23° or 24° C., which exceeds the minimum temperature for spawning of the Japanese species, namely 20°. Near them therefore it should be possible to establish beds replenished by their own spat. In the colder waters of the Sound, as at Crescent and at Samish, the reproductive cells are formed but are not discharged; they are reabsorbed within the glands in the autumn.

Spat from native and eastern oysters is still to be found, and it is stated that recent falls of spat have included a significant number of young Japanese oysters at places in the bay separated by a distance of nearly thirty miles. Both native and eastern oysters grow more rapidly in Willapa Bay than in the Sound.

Eastern oysters were first planted in Willapa Bay in 1894, when a few were brought from New York. More were introduced between about 1906 and 1912, but they have failed to produce spat on a commercial scale. The present plantings are very small, and the oysters are marketed not many weeks after their arrival.

Visit to Nanaimo and Ladysmith Bay, Vancouver Island.

Mention has been made of oyster beds at Ladysmith, Vancouver Island, where methods differ from those in use at Crescent, although the two places have the same latitude. The native oyster occurs further north as far as Queen Charlotte Sound, but fisheries are few on the coast in that direction. To see these beds and visit Nanaimo I returned to Vancouver on Sept. 22nd.

The crossing to Nanaimo was made by the morning boat next day. Dr. CLEMENS, director of the Biological Board's station on Departure Bay, met me on the quay and took me to his headquarters where I spent the afternoon and evening. This station serves as a base for workers carrying out investigations at a distance, some of them perhaps on freshwater problems, and provides as well facilities for post-graduate and vacation workers from the University of British Columbia and elsewhere. As at St. Andrew's, N.B., there are good working quarters and comfortable accomodation is provided in the residence, but the station is on a somewhat smaller scale.

At no other point on the tour was such clear water to be seen as there was in this bay near the station. The movements of bottom-living animals could be watched. On the other hand, murkiness of the atmosphere due to smoke from forest fires, unfortunately prevalent after an exceptionally dry summer, prevented appreciation of the more distant surroundings. The devastation caused by these forest fires was amply evident in the stretch of one hundred and fifty miles of country which separates Vancouver and Seattle.

On the following day Dr. CLEMENS took me to the grounds of the Ladysmith Oyster Company situated some ten miles south of Nanaimo. Low water was at noon, but the beds were not uncovered during our visit, the tides then being neaps. We were able to row over the beds and see the nature of the bottom which is largely gravel or other hard material.

Oyster Culture in Ladysmith Harbour, Vancouver Island.

The natural ground here does not exceed about two hundred acres in area. Part of it is leased to the Ladysmith Oyster Company. The chief point of interest is the culture of the native oyster on the gravel bottoms without dyked enclosures; the beds are kept just covered with water at low spring tides by an arrangement of baffle boards. Brown algae grow freely on these bottoms and have to be cleared away periodically. Spat is caught on shell cultch; thus in 1930 some thirty tons of shells were put out, which secured from one to fifty spat per shell. The set of spat is poor where the shells are dry at low tide.

The Japanese oyster was first introduced about 1914, when a small deposit was made for immediate disposal. Since then a few Japanese oysters have been picked up throughout the whole bay, some attached to local rock, evidently descendants of a few of the original lot which escaped marketing. Some of these original survivors had reached 20 cm. in length by the year 1925. The oysters collected by Mr. Jones of the Ladysmith company were planted by him in small lots in various places to ascertain where they thrived best. Japanese seed oysters are now being imported and grown along with the natives chiefly for sale in Vancouver and Victoria, where the demand for oysters greatly exceeds the supply. Investigations were made by Mr. Elsey, on reproduction in the Japanese oyster, first at the Nanaimo station, then at Ladysmith in a small concrete tank adjacent to the premises of the oyster company. Spawning occurred at a temperature between 20° and 21° C. This is evidently not attained with the regularity necessary for production of spat in this bay on a commercial scale.

A few eastern oysters are to be found, the remains of a load brought over in 1912.

Visit to the Atlantic Coast.

The return journey was made via Seattle and Chicago to New York, where I arrived early on Monday Sept. 29th, to spend the day in the city at the Pease Laboratories, the headquarters of an extensive consulting practice, where investigations are undertaken in chemical, biochemical, and bacteriological problems. In particular, research for the oyster industry is carried out on behalf of the Oyster Dealers and Planters Association of North America, whose president, Mr. Howard Beach, together with Mr. Prytherch of the U. S. Bureau of Fisheries, and members of the laboratory staff, I met there by appointment. The morning passed rapidly in interesting conversation; the afternoon was spent in looking round the laboratories. Research work in progress included an investigation on the remedial values in anaemia of normal and green oysters.

On Tuesday Sept. 30th Mr. Phillips (executive secretary of the Pease Laboratories) took me to the premises of the Blue Points Company at West Sayville, Long Island, on Great South Bay, where the oyster research laboratory run by Dr. Pease for the Oyster Growers' Association is situated.

The oyster hatchery designed by Mr. Firth Wells had been taken over by his former assistant, Mr. Glancy, and used for investigating the food of larvae and also for producing densely set spat. The object

was to explore the practical possibilities of removing and resetting it, spaced out so that each young oyster had room to grow. This spat derived from artificially fertilised eggs was induced to set on soaked partition collectors. Within a short time after attachment the larvae were carefully brushed off and sprinkled over strips of tough paper lying flat in a shallow trough containing water, where they were left to reset. They were then transferred to a suitable place for growth observations.

The hatchery procedure was described to me by Mr. GLANCY as follows:— artificial fertilizations are made in 5 gallon glass bottles. After six hours the embryos swimming at the surface are siphoned off and transferred to stoneware jars of 100 gallons capacity, with conical bottoms fitted with 3-way taps for drawing off the contents and also for introducing air under pressure. The air is supplied from a reservoir in which the pressure is maintained automatically at 3 lbs. per square inch by a compressor. A tank on the roof supplies water for a daily change in the jars through a Sharples centrifuge, fitted with a long tube and bowl, running at about half speed, i. e. about 7,500 revolutions per minute, delivering 10 gallons per minute of water cleared of all but the finest suspended particles and organisms which serve as food for the larvae. The water contained in each jar is emptied daily for seven days through a Delaval separator running at about 7,000 revolutions per minute, and the larvae thus concentrated are restored to the replenished jar where a fresh supply of food is available. After that period the larvae are large enough for separation by wire screens, this procedure being simpler than the use of the separator. On reaching the setting stage, ascertained by size and appearance, the larvae are transferred to setting tanks containing collectors.

As an instrument for research this apparatus is regarded as useful, but the opinion now held of such a method as a basis for the production of spat on anything like an adequate commercial scale is that the initial outlay and running cost would be prohibitive, and the results not necessarily certain.

The Oyster Industry of Great South Bay.

A comprehensive account cannot be given here, but a few outstanding points may be noted. The bay is of chief importance as a growing and marketing area. Seed brought in great quantities from the Connecticut shores is planted and grows well. The largest company, the Blue Points Company, sends away up to 600 barrels of oysters containing 3 bushels (or from 600 to 1200 oysters) per day, i. e. a maximum of about half a million a day. The four other companies in the bay together deal with

about the same amount, making the highest output about a million a day for the whole bay. When dredged the oysters are put into barrels, which on being landed are hoisted up and emptied into hoppers delivering to the sorting benches. There the marketable oysters are sorted into 3 sizes. The smallest are sold for eating on the half shell, and the rest are opened and shucked, fetching $2.50 to $3 per gallon. An opener averages per hour 2 gallons each containing 200 to 250 oysters. The opening house here is hardly up to the standard of that at Olympia in construction, but similar hygienic regulations are observed.

A characteristic of this shallow bay is good setting of spat, followed soon after by inexplicable mortality. The number of spawning oysters present in these more or less enclosed waters is enormous, and over a thousand larvae per gallon have been recorded. Very dense sets are obtained; thus in 1930 two partition collectors caught 3,000 spat. A heavy mortality therefore is not necessarily disastrous.

During the afternoon at West Sayville, it was possible to see something of oysters being landed, sorted, shucked and packed, and their storage in shallow tanks with chlorinated water. The following day Long Island Sound was crossed by ferry from Port Jefferson to Bridgeport, and New Haven was reached about mid-day, Mr. Glancy taking me in his car. Mr. Howard Beach arranged for us to board one of his oyster boats, which was dredging cultch heavily laden with new spat, and taking it from New Haven Harbour to the growing grounds outside. He had achieved an interesting result in securing a second spat up the river at New Haven by laying there oysters taken from cooler waters elsewhere on the coast before they had spawned, thus obtaining a second spawning. The spat in the harbour was very dense in 1930; the cultch was completely covered with young oysters, already half an inch across in early October. At his headquarters preparations were in progress for experimental treatment of certain beds with copper sulphate to eliminate starfish, which are a serious pest on the beds. An elongated bag of sacking, containing crystals of the salt, was enclosed in wirework attached to a special dredge frame, for hauling over the bottom.

Oyster Culture in Long Island Sound.

The Connecticut coast is a great oyster seed producing region. The growing of oysters for market has been largely discontinued because, on account of sewage and industrial pollution, the waters of most of the inlets are no longer suitable for that purpose. Extensive cultching operations are undertaken in the early summer, thousands of bushels

of shells being put out. Spat thus caught is dredged up and transferred for growing in late September or early October to grounds further off shore. After two years it is sold to growers in Great South Bay. Good seed grounds, such as those off Stratford Shoal, are worth $1,000 an acre. The annual lease costs only $2 or $3 per acre.

Motor-driven oyster boats of the type used at New Haven have a crew of about seven, and are 56 feet in length, 16 ft. beam and 5 ft. 6 ins. draught. They are capable in a day of dredging and moving eight

Fig. 5. A motor oyster boat dredging spat-covered cultch in New Haven Harbour, Connecticut.

or nine thousand bushels of spat. Two dredges are used alternately one each side forward of the wheel house, from which hauling is controlled by the skipper without diversion of his attention from the wheel. The warps pass through blocks attached to a stout vertical post in the middle of the deck at about six feet from the ground. The dredges are four feet wide. This arrangement differs considerably from that to be found in Dutch or Danish oyster boats, in which up to a dozen dredges are worked simultaneously over a specially wide stern, the blocks being suspended from a horizontal cross bar. The deck capacity is increased by the fitting of side boards, which permit the heaping up of shells on each side of the wheel house.

Visit to Philadelphia and to Delaware Bay.

The journey to Delaware Bay was broken at Philadelphia, where I spent the morning with Mr. Prytherch at the University of Penn-

sylvania. Continuing this year his work at Milford Harbour (Long Island Sound) on the distribution and setting of oyster larvae, he had also completed a motion picture showing spawning of the oyster, and development of the embryo and larva up to and including the actual process of attachment. This intensely interesting film he kindly showed. It was possible to distinguish the diffuse cloud of sperm from the abrupt jets of eggs emitted by the female during spawning. During setting, the action of the foot could be followed. Setting was induced apparently by the presence of copper due to the brief immersion of a coin.

Meanwhile Professor Thurlow Nelson of Rutgers University had started by road from New Brunswick, N. J., and met me at Camden Ferry, on the Delaware river opposite to Philadelphia. A noted canning company has its works beside the ferry terminal. It was the tomato season, and rejected tomatoes were floating freely nearby. We went on to Port Norris, near Maurice River Cove, and spent the night at the bungalow of his brother R. J. Nelson, who accompanied us next day (Saturday Oct. 4th), when we started soon after 6 a.m. for the Oyster Investigation Laboratory at Bivalve on Maurice River Cove, and thence set out in the oyster boat used for investigations. On the grounds in the bay near the entrance to the cove a line of wire cage traps for whelk drills, baited with spat, was picked up and examined, together with samples of the season's spat. On the way back we stopped to examine one of the storage floats. These correspond to some extent to the French bassins de degorgement, but as they are situated in water usually less salt than that in the bay, the oysters undergo a definite "plumping" or "floating", taking up a small percentage of water. A distinct clearing of the water in the floats could be observed. Having returned to Bivalve we visited one of the opening houses, where a staff of about 20 were at work, encouraged by radio music.

Our next visit was to a point on the Cape Shore some thirty miles distant. Close inshore were wire netting bags containing cultch which had caught a very satisfactory spat. A feature of this locality is the long period during which setting is practically continuous.

Oyster Culture in Delaware Bay.

As in most of the rivers and inlets of the New England coast, good natural beds occurred in this bay. Those near the dividing line between New Jersey and Delaware were exploited with special eagerness by oystermen from both States, and became the subject of rivalry and dispute. While negotiations between the two States for the allocation

of the beds were dragging on, the matter was settled by the complete exhaustion of the beds in question. Other natural beds were rapidly approaching exhaustion when conservation measures were enforced by the State. Some 30,000 acres are now cultivated under lease, and the number of men employed in the oyster business of Maurice River Cove, the most important oyster centre in New Jersey, is from 2,500 to 3,000. Certain areas are reserved for tonging by poorer men, numbering about 150, who are unable to run boats for dredging. The public beds are

Fig. 6. An oyster storage float moored in one of the reaches of Maurice River Cove, Delaware Bay.

cultched co-operatively by the State and oystermen, the State contribution to the cost being derived from a tonnage tax on dredging vessels. There are about 250 licensed boats — auxiliary sailing schooners — which land annually over four hundred million oysters, mostly at Bivalve, where for two or three weeks at the height of the season, four freight trains of eighty cars are despatched daily; the sacks of oysters being packed in one layer, covering the bottom of each car. The markets are chiefly in Pennsylvania, Philadelphia taking a very large proportion. On account of the muddiness of the water in the bay, storage of oysters in floats in the clearer water of the cove is practised, which, as already mentioned, normally has a slight plumping effect on the oysters. Supervision is exercised by the State Health Service, whose regulations are

enforced in the opening and shipping houses. A launch stationed at Bivalve is maintained by the Health Service for inspection work.

Investigations on the distribution and setting of larvae have been carried out for a number of years by Professor NELSON — continuing the work of his father JULIUS NELSON — both in Delaware Bay and in Barnegat Bay. Reactions of larvae to changes in salinity and current velocity have been noted, offering an explanation of the distribution of larvae and spat in these two localities, which exhibit striking hydrographical differences.

Conclusion.

The return journey to Prince Edward Island was completed on Oct. 7th, and that to England followed at the end of the month.

As may well be understood, it is felt that the value of a tour such as this lay even more in the personal contacts made, with their opportunities for comparing experiences, than in the information collected, some of which is already available in papers which have been consulted.

The writer desires here to offer an apology for any inaccuracies which may appear in this article, due to lack of opportunity for obtaining the criticisms of his informants, to whom he is much indebted. He also desires to express sincere appreciation for kindness and hospitality shown by the directors and staffs of the biological stations and laboratories visited, for the giving of their time during week-ends by two busy professors, and not least for the essential part taken by the English Fisheries Department.

Zur Bestimmung des Triftstromes aus Terminbeobachtungen.

Von

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1. Das Strommaterial.

Die in der Ostsee als Terminbeobachtungen auf den Feuerschiffen ausgeführten Strommessungen sind in mancher Hinsicht für eine Prüfung der Triftstromtheorie nicht besonders geeignet. Auch wenn man von den direkten Messungsfehlern und Mängeln der Methode (Methode mit Boje und Strom-Stromkreuz) ganz absieht, sind grosse Abweichungen von den idealen Verhältnissen zu erwarten. Die Feuerschiffe sind in der Nähe der Küsten oder grösserer Untiefen stationiert, woraus sich Störungen ergeben, welche sich kaum vollständig überblicken lassen. Weiter bedingt die Begrenzung der verschiedenen Meeresteile immer Wasserstauungen, welche nicht nur von dem lokalen Wind, sondern auch von den Windverhältnissen in angrenzenden Meeresteilen und weiter von der Topographie des Meeresbodens abhängig sind. In dem besonders im Sommer stark geschichteten Ostseewasser verursacht der Wind sehr bemerkenswerte Veränderungen des internen Solenoidfeldes, woraus weiter Konvektionsströmungen entstehen. Die wirkliche Strömung ist somit eine Resultierende dieser drei verschiedenen Stromarten, deren innerer Zusammenhang oft sehr kompliziert ist. Dazu kommen schliesslich noch die Schwingungen periodischer Natur, die freilich in der Ostsee von geringerer Bedeutung sind, und die meteorologisch bedingten Schwingungen aperiodischer Natur, durch welche die Strömung oft sehr kräftig beeinflusst wird.

Wenn man der Behandlung ein grösseres Material von Terminbeobachtungen zu Grunde legt, können diese Störungen aperiodischer Art zum grossen Teil eliminiert werden, sofern das Material in geeigneter Weise gruppiert wird. Wie vollständig diese Eliminierung der von den Schwin-

gungen verursachten Störungen wird, lässt sich zwar nicht ganz überblicken, aber es scheint mir doch berechtigt zu sein, die Theorie der stationären winderzeugten Strömungen in dieser Weise zu prüfen.

V. W. Ekman hat an verschiedenen Beispielen gezeigt, wie sich die winderzeugten Strömungen in begrenzten Meeren gestalten müssen[1]). Bei langgestreckten Meeren sind infolge der Wasserstauung kräftige Tiefenströme (Gradientströme) zu erwarten, welche hauptsächlich durch die Längsrichtung des Meeres bestimmt sind. In einem rings geschlossenen Meere dagegen kann ein kräftigerer Tiefenstrom nicht entstehen; die Richtung des Windstaus fällt hier fast in die Richtung des Windes. In diesem letzteren Falle, wo der Staustrom im Verhältnis zum reinen Triftstrom in den obersten Schichten klein wird, scheint ein Vergleich zwischen Theorie und Beobachtungen am geeignetsten zu sein.

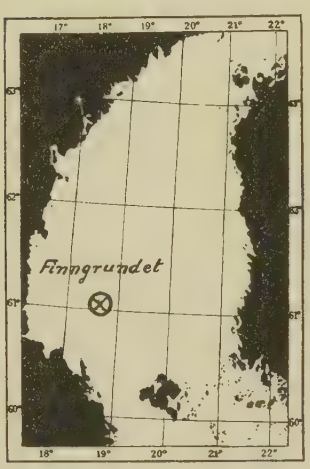

Fig. 1. Lage des Feuerschiffes Finngrundet.

In einer kürzlich erschienenen Arbeit über die Strömungen im nördlichen Ostseegebiet habe ich u. a. auch die Frage der Prüfung der Ekmanschen Triftstromtheorie behandelt[2]). Von den in diesem Gebiet stationierten Feuerschiffen kommt vor allem das schwedische Feuerschiff Finngrundet (Position: 60°02′ N, 18°31′ E. in der Bottensee) in Frage; die anderen Feuerschiffe liegen so, dass kräftige küstenparallele Tiefenströme zu erwarten sind. Eine vorläufige Berechnung hat diese Annahme bestätigt, wie auch eine frühere Untersuchung von R. Witting zeigte[3]). Zwar fand Witting eine deutliche Ablenkung des Oberflächenstromes nach rechts von der Windrichtung, aber die starke Elliptizität der Stromellipsen der verschiedenen Feuerschiffe zeigt deutlich, dass man an allen diesen Stationen mit einer bevorzugten Strömungsrichtung zu rechnen hat. Zwar entsprechen die Verhältnisse bei Finngrundet auch nicht vollständig einem rings geschlossenen Meere, aber die freie Lage und die ziemlich engen Verbindungen der Bottensee mit den anderen Meeres-

1) Vgl. V. W. Ekman, Beiträge zur Theorie der Meeresströmungen. Annal. d. Hydrogr. 1906, S. 527.

2) E. Palmén, Untersuchungen über die Strömungen in den Finnland umgebenden Meeren. Soc. Sc. Fenn. Comm. Phys.-Math. V. 12, Helsingfors, 1930.

3) R. Witting, Zur Kenntnis des vom Winde erzeugten Oberflächenstromes. Annal. d. Hydrogr. 1909, S. 193.

gebieten gestalten doch die Verhältnisse hier viel günstiger als bei den anderen Feuerschiffen. Auch die folgenden Ergebnisse bekräftigen diese Annahme (vgl. besonders Fig. 2).

Das in Frage kommende Material von Strom- und Windbeobachtungen beschränkt sich somit auf die Terminbeobachtungen bei Finngrundet. Untersucht wurden die Beobachtungen der Jahre 1923 bis 1927[1]). Die Strommessungen sind regelmässig am Morgen in den Tiefen 0 und 20 m ausgeführt; bei eisbedecktem Meer wird das Feuerschiff eingezogen, sodass für die Zeit Januar—April selten Beobachtungen vorliegen; die Beobachtungen des Jahres 1925 sind jedoch vollständig. Insgesamt wurden 1403 Strommessungen in jeder Tiefe behandelt.

2. Zusammenstellung der Beobachtungen.

Die Windbeobachtungen wurden für jede Beaufortzahl in folgende acht Gruppen nach der Windrichtung zusammengestellt: (N), (NE), (E), (SE), (S), (SW), (W) und (NW), und für jede Windstärkengruppe wurde sowohl der resultierende Wind (in Beaufort) wie der resultierende Strom (in cm/sec) vektoriell berechnet. Auf diese Weise erhält man eine erste, rohe Beziehung zwischen Wind und gleichzeitigem Strom in den Tiefen 0 und 20 m. Aus den in dieser Weise ermittelten Werten sind nach dem oben Gesagten die Störungen des stationären Zustandes wenigstens zum grossen Teil eliminiert. Vergleicht man die Stromvektoren der einzelnen Windgruppen, so findet man aber, dass gewisse Richtungen bevorzugt sind, und zwar derart, dass nördliche Winde regelmässig viel kräftigere Strömungen verursachen als gleich starke südliche Winde. Dies deutet darauf hin, dass man es hier mit einer Superposition eines »permanenten« Strom zu tun hätte, der vom Wind unabhängig wäre. Eine nähere Untersuchung zeigt jedoch, dass eine deutliche Beziehung zwischen der Windstärke und dieser aus der Asymmetrie ermittelten »Restströmung« vorhanden ist. Die Geschwindigkeit der Restströmung nimmt nämlich sehr auffällig mit der Windstärke zu.

Diese Restströmung wurde in folgender Weise aus der Asymmetrie berechnet. Bei reinem Triftstrom muss man erwarten, dass die Resultante der Stromvektoren der acht Windgruppen bei gleicher Windstärke verschwindet. Trifft dies aber nicht zu, sondern erhält man eine deutliche Restresultante, so repräsentiert diese gerade den gesuchten Reststrom, welcher jedenfalls nicht lediglich auf lokalem Wind beruht. Eine etwas

[1]) Svenska Hydr.-Biolog. Komm. Fyrskeppsundersökningar, 1923—1927.

andere Methode hat H. U. Sverdrup vorgeschlagen[1]). Bei reinem Triftstrom liegen die Endpunkte der Stromvektoren der verschiedenen Windgruppen (bei konstanter Windstärke) auf einer Kreislinie mit dem Ausgangspunkt der Stromvektoren als Zentrum. (Im Falle eines deutlichen Küsteneinflusses ist die Kreislinie durch eine Ellipse zu ersetzen.) Man hat daher nur eine durch die Endpunkte der Stromvektoren gehende Kreislinie zu zeichnen und die Endpunkte mit dem Zentrum zu verbinden, um den Reststrom und den Triftstrom zu bestimmen. In Fig. 2 ist dieser Reststrom für die Windgruppen 2—6 Beaufort (als Mittel) zum Vergleich nach den obigen Methoden graphisch wiedergegeben. S, SW, u.s.w. geben die Windrichtung der entsprechenden Stromvektoren an. Die Vektoren $\overrightarrow{FC}$ und $\overrightarrow{FC'}$ bezeichnen den nach den beiden Methoden berechneten Reststrom, und zwar $\overrightarrow{FC}$ nach der Sverdrupschen Methode und $\overrightarrow{FC'}$ nach der hier benutzten. Die entsprechenden Resultanten sind

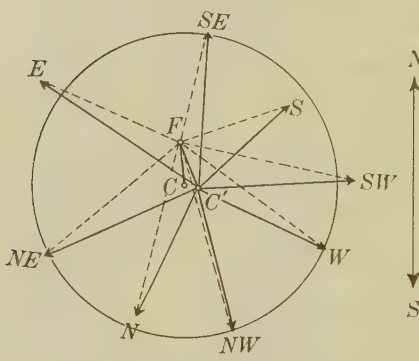

Fig. 2.
Berechnung des Reststromes.

N 7° W 2.4 cm/sec bzw. N 25° W 2.6 cm/sec.

Unter Stromrichtung wird hier und im folgenden die Richtung, aus welcher der Strom fliesst, angegeben.

Eine vollständige Übereinstimmung zwischen den nach den verschiedenen Methoden berechneten Restströmen ist nicht vorhanden, weil die Voraussetzungen natürlich nicht vollständig erfüllt sind. Eine beachtenswerte Tatsache ist es aber, dass der Reststrom von der Windstärke abhängig ist. Eine Gruppierung nach der Windstärke ergab als Resultat, dass der Reststrom in 20 m Tiefe fast derselbe wie an der Oberfläche war, was sich daraus erklärt, dass der Reststrom den Charakter eines Gradientstromes trägt. Man erhält die folgenden ausgeglichenen Werte:

Tab. 1. Charakteristischer Reststrom bei Finngrundet.

Windstärke Beauf.	Reststrom cm/sec	Windstärke Beauf.	Reststrom cm/sec
1	N. 25° W. 1.7	6	N. 25° W. 3.4
2	N. 25° W. 2.0	7	N. 23° W. 4.0
3	N. 25° W. 2.3	8	N. 20° W. 5.5
4	N. 25° W. 2.6	9	N. 15° W. 7.0
5	N. 25° W. 3.0	10	N. 10° W. 9.0

[1]) H. U. Sverdrup, The Wind-Drift of the Ice on the North-Siberian Shelf. The Norw. North Polar Exped. with the "Maud" 1918—1925, Scient. Res. Vol. IV, No. 1.

Eine Erklärung für diese Erscheinung ist darin zu suchen, dass jedes Feuerschiff eine solche charakteristische Restströmung aufweist, die im allgemeinen von den Restströmungen der anderen Feuerschiffe abweicht. Der resultierende Strom für die ganze Zeitperiode 1923—1927 war bei Finngrundet

in 0 m Tiefe: N 31° W 3.2 cm/sec, in 20 m Tiefe: N 29° W 3.3 cm/sec.

Überhaupt kann man sagen, dass der für jedes Feuerschiff charakteristische Reststrom der Richtung nach mit der vorherrschenden Strömungsrichtung nahe übereinstimmt. Diese letztere ist von der allgemeinen Horizontalzirkulation der einzelnen Meeresgebiete abhängig, und diese Horizontalzirkulation nimmt mit der Windstärke an Intensität zu[1]). Die Erscheinung beruht also letzten Endes auf den Begrenzungen des Meeres und der Erdrotation.

Den für die einzelnen Windgruppen erhaltenen Stromvektor, von dem Vektor des charakteristischen Reststromes nach Tab. 1 befreit, wollen wir im folgenden vorläufig den Triftstrom nennen. Der charakteristische Reststrom trägt den Charakter eines Gradient- oder Staustromes. Durch das obige Verfahren wird ein Teil der tatsächlich vorhandenen Stauströmung eliminiert. Ein Versuch zu weiterer Eliminierung der Einwirkung des Wasserstaues wird später versucht.

3. Vorläufige Beziehung zwischen Wind und Strom.

Die in der obigen Weise von dem Einfluss des charakteristischen Reststromes (oder der typischen Horizontalzirkulation) befreiten Stromresultanten geben ein deutliches Bild von der Beziehung zwischen Wind und Strom, wie die folgenden Tabellen 2 und 3 zeigen. In Tab. 2 ist eine Gruppierung nach der Windstärke, in Tab. 3 nach der Windrichtung vorgenommen. Hier und im folgenden bezeichnen:

V_z Stromgeschwindigkeit in cm/sec in der Tiefe z (m);
f Verhältnis zwischen Stromgeschwindigkeit in 20 m und in 0 m Tiefe;
v Windgeschwindigkeit in m/sec;
λ Verhältnis zwischen Strom- und Windgeschwindigkeit;
α_z Ablenkung des Stromes von der Windrichtung (posit. »cum sole«);
$\Delta\alpha$ Drehung der Stromrichtung nach rechts zwischen Oberfläche und 20 m Tiefe.

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[1]) Vgl. näher E. Palmén, l. c. S. 6—17.

Tab. 2. Strom bei verschiedener Windstärke.

Windstärke Beauf.	V_0	V_{20}	f	α_0	α_{20}	$\Delta\alpha$
1.0	2.0	1.6	0.80	26°	32°	6°
2.0	3.1	2.2	0.71	41°	50°	9°
2.9	5.8	4.5	0.78	38°	48°	10°
3.9	8.4	6.2	0.74	33°	42°	9°
4.9	11.3	9.6	0.85	34°	41°	7°
5.9	12.3	10.2	0.83	35°	45°	10°
6.8	14.7	13.0	0.88	32°	52°	20°
7.8	19.2	18.3	0.95	25°	38°	13°
9.0	22.9	19.7	0.86	36°	40°	4°
9.9	27.3	24.1	0.88	8°	11°	3°
11—12	(40.0)	(33.0)	(0.83)	(34°)	(29°)	(—5°)

Für die Windstärke 11—12 Beauf. sind die rohen Werte angegeben. Bei der Gruppierung nach der Windrichtung wurden Mittelwerte für die Windstärkegruppen 2—7 Beaufort gebildet, und zwar in der Weise, dass jeder Gruppe derselben Wert gegeben wurde.

Tab. 3. Strom bei verschiedener Windrichtung. (Mittel aus den Gruppen 2—7 Beauf.)

Windrichtung	V_0	V_{20}	f	α_0	α_{20}	$\Delta\alpha$
(N.)	8.6	6.8	0.79	30°	39°	9°
(NE.)	11.2	9.6	0.86	35°	46°	11°
(E.)	12.1	11.5	0.95	41°	47°	6°
(SE.)	9.7	6.8	0.70	41°	46°	5°
(S.).....	7.5	5.5	0.73	40°	55°	15°
(SW.).....	9.2	7.9	0.86	38°	50°	12°
(W.)	7.4	5.7	0.77	22°	41°	19°
(NW.)	8.2	7.0	0.85	34°	47°	13°
Mittel ...	9.2	7.6	0.81	35°	46°	11°

Nach den obigen Tabellen hat man eine deutliche Beziehung zwischen Wind und Strom im Ekmanschen Sinne. Besonders bemerkenswert ist die empirische Bestätigung der Drehung der Stromrichtung mit der Tiefe. Bis jetzt liegen sehr wenige andere Beobachtungen über diese Drehung vor[1]). Nach Tab. 3 besteht aber nicht volle Symmetrie, was wohl auf Küsteneinflüsse, Einwirkung der Bodentopographie, Mängel der Methode u. s. w. zurückzuführen ist. (Die kräftige Strömung in den Gruppen (NE) und (E) scheint übrigens zum Teil durch zufällig sehr kräftige Stromresultanten in der Windstärkegruppe 7 Beauf. bedingt zu sein.)

[1]) Vgl. die von H. U. Sverdrup in einem Spezialfall gefundene Drehung. (The Waters on the North-Siberian Shelf. Norw. North Polar Exp. Vol. IV, N:o 2, S. 107.)

Bei der Messung des Stromes mit Stromkreuz und Boje, wie bei den Feuerschiffen, erhält man keine ganz ungestörte Tiefenströmung, sondern muss mit einer gewissen Einwirkung des Oberflächenstromes rechnen. Ich versuchte daher (vgl. die früher zitierte Abhandlung S. 26) diese Einwirkung approximativ zu eliminieren, was jedoch mit Schwierigkeiten verknüpft ist, da eingehende empirische Untersuchungen dazu nötig wären. Auf Grund verschiedener Erwägungen wurden die folgenden für etwa 4 bis 5 Beauf. geltenden Mittelwerte gefunden:

Tab. 4. Korrigierte Mittelwerte. (Windstärke 4 bis 5 Beauf).

V_0: 9.2 cm/sec, α_0: 35°
V_{20}: 7.0 cm/sec, α_{20}: 54°
f: 0.76 , $A\alpha$: 19°

Im Mittel wäre also für die Windstärken 2—7 Beauf. der Oberflächenstrom um 35° und der Strom in 20 m Tiefe um 54° nach rechts von der Windrichtung abgelenkt, was einer Drehung um 19° »cum sole« zwischen diesen Tiefen entspricht. Gleichzeitig nimmt die Stromgeschwindigkeit bis zu 0.76 ihres Wertes an der Oberfläche ab.

Vergleicht man diese Werte mit den Forderungen der ursprünglichen Triftstromtheorie von Ekman, so findet man für einen konstanten Wert der virtuellen inneren Reibung, der ungefähr den von Sverdrup gefundenen Werten von 200—300 entspricht, gute Übereinstimmung zwischen Theorie und beobachtetem Werte inbetreff der Ablenkung der Strömung, aber dagegen keine genügende Übereinstimmung für die Abnahme der Stromgeschwindigkeit gegen den Meeresboden. Die in Tab. 4 enthaltene Stromabnahme ist nämlich viel zu klein, um in Übereinstimmung mit der Annahme eines konstanten Reibungskoeffizienten gebracht werden zu können. Bei einer Tiefe von etwa 23 m (durchschnittliche Tiefe bei Finngrundet nach den Seekarten) müsste das Verhältnis f bei dem angenommenen Wert der inneren Reibung etwa 0.12 statt des obigen Wertes 0.76 werden, was zeigt, dass die einfache Theorie nicht im Stande ist, die tatsächliche Geschwindigkeitsverteilung zu erklären. Eine etwas bessere Übereinstimmung könnte man erhalten, wenn man einen mit der Tiefe variablen Reibungskoeffizienten nach den späteren Versuchen von u. a. Ekman[1]), Sverdrup und Fjeldstad[2]) annimmt. Hätte man Strommessungen in mehreren Tiefen zur

[1]) V. W. Ekman, Eddy-Viscosity and Skin-Friction in the Dynamics of Winds and Ocean-Currents. Memoirs of the Royal Meteor. Society, Vol. II, N:o 20.

[2]) J. E. Fjeldstad, Ein Beitrag zur Theorie der winderzeugten Meeresströmungen. Gerlands Beiträge zur Geophysik, Bd. 23, S. 237.

Verfügung, so wäre es vielleicht möglich, aus der Stromverteilung empirische Werte für die innere Reibung in ihrer Beziehung zum Abstand von der Meeresoberfläche abzuleiten. In unserem Falle können wir nur die Oberflächenströmung näher behandeln und müssen uns damit benügen, eine tatsächlich vorhandene Rechtsdrehung der Stromrichtung gegen den Meeresboden festgestellt zu haben. Es ist übrigens zu bemerken, dass die Tiefenstrombeobachtungen mittels Stromkreuz und Boje wohl kaum für eine genauere, quantitative Behandlung geeignet sind.

4. Nähere Untersuchung der Beziehung zwischen Wind und Oberflächenströmung.

Um eine quantitative Beziehung zwischen Wind und Oberflächenstrom festzustellen, ist es notwendig, die in Beaufort angegebenen Werte der Windstärke in m/sec umzurechnen. Hierbei hängt das Ergebnis natürlich wesentlich von der benutzen Umrechnungsskala ab, da exakte Windmessungen nicht vorliegen. Durch vergleichende Untersuchungen der Windstärkeschätzungen an den verschiedenen Feuerschiffen bin ich zu der Überzeugung gekommen, dass die bekannte Köppensche Beaufortskala den Verhältnissen an den Feuerschiffen am besten entspricht. Die anderen gebräuchlichen Skalen würden nämlich unwahrscheinlich hohe Werte der Windgeschwindigkeit bei höheren Beaufortzahlen geben, was auch ein Vergleich zwischen den gleichzeitigen Windbeobachtungen an dem Feuerschiff Äransgrund (ausserhalb Helsingfors) und den Windmessungen am aerologischen Observatorium Ilmala bei Helsingfors zu bestätigen scheint[1]). Durch Umrechnung erhält man folgende Werte:

Tab. 5. Wind- und Oberflächenstromgeschwindigkeit.

Wind		V_0	$10^2 \cdot \lambda$
Beauf.	m/sec		
1.0	1.7	2.0	1.18
2.0	3.1	3.1	1.00
2.9	4.6	5.8	1.26
3.9	6.5	8.4	1.29
4.9	8.6	11.3	1.31
5.9	10.5	12.3	1.17
6.8	12.5	14.7	1.18
7.8	14.9	19.2	1.29
9.0	18.0	22.9	1.27
9.9	20.7	27.3	1.32

Die Werte λ in der obigen Tabelle weisen eine fast lineare Beziehung zwischen Windgeschwindigkeit und Geschwindigkeit

[1]) Vgl. E. Palmén, l. c. S. 38.

des Oberflächenstromes auf. Nur für sehr schwachen Wind (1 bis 2 Beauf.) scheint die Abweichung etwas grösser zu sein, was vielleicht darauf beruht, dass die Köppensche Skala bei sehr schwachem Wind nicht so gut den Schätzungen entspricht. Schreibt man nach der Ekmanschen Theorie

$$V = \frac{T}{\sqrt{2\mu\varrho\omega\sin\varphi}}$$

wo T den in der Meeresoberfläche wirksamen Tangentialdruck des Windes, ϱ die Dichte des Wassers, ω die Winkelgeschwindigkeit der Erdrotation und φ die geographische Breite bezeichnet, so wird die für bestimmte Werte der Dichte und Reibung universelle Konstante

$$\lambda\sqrt{\sin\varphi} = 1.14\cdot 10^{-2}.$$

Dieser Wert stimmt ziemlich gut mit entsprechenden Werten anderer Forscher überein[1]). Wesentlich grössere Werte haben dagegen Nansen, Sverdrup und Brennecke durch Studium der Eistrift gefunden, aber hierbei ist, wie Sverdrup bemerkt, zu beachten, dass Eis unter gewissen Bedingungen das Zustandekommen einer kräftigeren Triftströmung befördert[2]).

Die obige Beziehung zwischen Wind und Oberflächenstrom möchten wir noch nicht als endgültig ansehen. Bei der Eliminierung der Restströmung wurde zwar ein Teil der Wasserstauung beachtet (vgl. S. 291), aber in den obigen Resultaten ist sicherlich noch ein Teil des Wasserstaues unbeachtet geblieben, und zwar diejenige Komponente, welche direkt vom Winde abhängt. In einem rings geschlossenen Meere fällt diese Komponente des Wasserstaues ungefähr in die Windrichtung. Die Grösse des direkten Windstaues hat R. Witting für die Ostsee empirisch bestimmt; er fand dabei, dass die Stauwirkung des Windes etwa 1.6 der statischen Wirkung der dem Winde entsprechenden Luftdruckverteilung beträgt[3]). In unserem Falle kann der Luftdruckeffekt unbeachtet bleiben, da die vom Luftdruckgradienten verursachte Neigung gerade dem statischen Gleichgewichtszustande entspricht. Wie bekannt ist die Windstauung nicht nur vom Wind, sondern auch von anderen Umständen wie z. B. der Wassertiefe abhängig. Wir können daher hier

[1]) Vgl. H. Thorade, Die Geschwindigkeit von Triftströmungen und die Ekman'sche Theorie. Annal. d. Hydrogr. XXXXII, S. 379, 1914.

[2]) H. U. Sverdrup, Die Eistrift im Weddelmeer. Annal. d. Hydrogr. LVI, S. 265, 1928.

[3]) R. Witting, Hafsytan, Geoidytan och Landhöjningen utmed Baltiska havet och Nordsjön. Fennia 39, N:o 5.

nur eine ganz approximative Schätzung vornehmen; die vom Winde erzeugte Neigung der Meeresoberfläche nehmen wir im stationären Zustande als der Windgeschwindigkeit proportional an.

Die Bestimmung des Windstaus können wir nach zwei verschiedenen Methoden vornehmen. Erstens kann man die Wasserstandsbeobachtungen für zwei oder mehrere Stationen nach dem gleichzeitigen Wind gruppieren, um daraus die jedem Wind entsprechendende Neigung zu bestimmen. Solche Bestimmungen hat WITTING für mehrere Gebiete vorgenommen[1]). Für die südliche Bottensee (also für die Gegend, wo Finngrundet stationiert ist) erhielt WITTING Resultate, welche ziemlich gut mit einigen von mir ausgeführten gleichartigen Bestimmungen des Windstaus im Finnischen Meerbusen übereinstimmen. Bei diesen Werten ist der Luftdruckgradient jedoch nicht vollständig eliminiert. Nach der zweiten Methode, welche sich auf das konstante Verhältnis zwischen dem reinen Windeffekt und dem Luftdruckeffekt gründet, kann man, da ja der statische Luftdrukeffekt bekannt ist, auch den reinen Windeffekt berechnen, wenn nur die mittlere Beziehung zwischen Luftdrukgefälle und Wind bekannt ist. Bei der Berechnung gehen wir davon aus, dass die Windgeschwindigkeit dem Luftdruckgradienten proportional ist, wie nach der einfachen Reibungstheorie von GULDBERG-MOHN. Bei exakteren Berechnungen wäre diese Reibungstheorie natürlich durch eine strengere zu ersetzen, aber in diesem Falle kann die einfache Theorie genügen. Als Mittelwert für das Verhältnis Wind zum Gradienten wählen wir den Wert 4 m/sec pro mm Hg und Meridiangrad (111 km)[2]). Daraus lassen sich die folgenden Werte für den statischen Effekt des Luftdruckes Δp_h, den reinen Windeffekt Δh_v (1.6 mal der Druckeffekt) und den stationären (reibungslosen) Windstaustrom V_s ableiten. Die Werte Δh_p und Δh_v bezeichnen die Hebung der Meeresoberfläche in mm bei einem Abstand von 100 km in der Richtung des Druckgradienten bzw. des Windes bei einer Windgeschwindigkeit von 1 m/sec:

$$\Delta h_p = 3.04,\ \Delta h_v = 4.86,\ V_s = 0.37 \text{ cm/sec.}$$

Die direkten Messungen von WITTING ergaben für die südliche Bottensee für Δh_v etwa den Wert 6.0; nach meinen Bestimmungen erhielte man für die Längsrichtung des Finnischen Meerbusens etwa den Wert 4 bis 5. Im folgenden werden wir mit dem obigen Wert $\Delta h_v = 4.8$ bzw.

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[1]) R. WITTING, Untersuchungen zur Kenntnis der Wasserbewegungen und der Wasserumsetzung in den Finnland umgebenden Meeren, I. Finnl. Hydr.-Biol. Unters. N:o 2.

[2]) Vgl. HANN-SÜRING, Lehrbuch der Meteorologie, 4. Aufl. S. 776—777.

$V_z = 0.37$ rechnen, und zwar unter der Annahme, dass der Windstau der Windgeschwindigkeit proportional ist. Der statische Effekt des Luftdruckes ist bei der mittleren Dichte des Wassers im Bottnischen Meerbusen etwa $13.5 \cdot \Delta b$, wo Δb das Luftdruckgefälle in mm Hg bedeutet. Graphisch kann mit Hilfe dieser Werte der reine Triftstrom bestimmt werden, wenn wir annehmen, dass der stationäre Staustrom unter Vernachlässigung der Reibung 90° nach links von der Windrichtung gerichtet ist. Wir erhalten somit folgende endgültigen Werte:

Tab. 6. Staustrom und reiner Triftstrom.

Windgeschw.	Staustrom	Triftstrom	$\lambda \cdot 10^2$	α_0
1.7	0.6	2.3	1.35	40°
3.1	1.2	3.9	1.26	53°
4.6	1.7	6.9	1.50	49°
6.5	2.4	9.8	1.51	45°
8.6	3.2	13.3	1.55	45°
10.5	3.9	14.8	1.41	47°
12.5	4.7	17.7	1.42	45°
14.9	5.6	22.1	1.48	38°
18.0	6.7	27.2	1.51	47°
20.7	7.7	29.0	1.40	24°

Die mittlere Ablenkung des Oberflächenstromes beträgt nach diesen Werten **43°.3**, und für $\lambda \cdot 10^2$ erhält man den Mittelwert **1.44**, woraus sich für die universelle Konstante $\lambda \sqrt{\sin \varphi}$ der Wert **1.35** ergibt. Lässt man den etwas unsicheren Wert der Ablenkung für die Windgeschwindigkeitsgruppe 10 Beaufort ausser Acht, erhält man eine mittlere Ablenkung von **45.4**.

Tab. 6 zeigt ausserdem, dass die Ablenkung durchschnittlich mit wachsendem Wind abnimmt, wie die folgenden Mittelwerte zeigen:

Windstärke in Beauf.:	1—3	4—6	7—10
Ablenkungswinkel:	47°3	45°7	38°5

In der ursprünglichen Ekman'schen Theorie ist die Ablenkung von dem Verhältnis zwischen Meerestiefe und Reibungstiefe abhängig; mit abnehmenden Werten für dieses Verhältnis nimmt auch die Ablenkung des Oberflächenstromes ab. Da jedoch der Koeffizient der inneren Reibung keine Konstante ist, ermöglichen die obigen Werte der Ablenkung nicht die Berechnung der Reibungstiefe. Nimmt man mit Ekman an, dass die Reibungstiefe etwa 600 mal die Stromgeschwindigkeit ist, so würde die Ablenkung für grössere Windstärke noch viel kleiner sein, als die obigen Werte angeben. Der Umstand, dass die Ablenkung so gross ist, deutet wieder darauf hin, dass der Koeffizient der inneren Reibung mit wachsendem Abstand von der Meeresoberfläche stark abnimmt, wie auch die Berechnungen von Sverdrup zeigten (vgl. S. 293).

Was den Wert für die Konstante $\lambda\sqrt{\sin\varphi}$ anbetrifft, so ist dieser nach Tab. 6 grösser als der Wert 1.26 von THORADE. Die Abweichung ist ziemlich gering und kann auf verschiedenen Fehlerquellen beruhen. Es ist ferner zu beachten, dass man wohl auch in dem von THORADE behan-

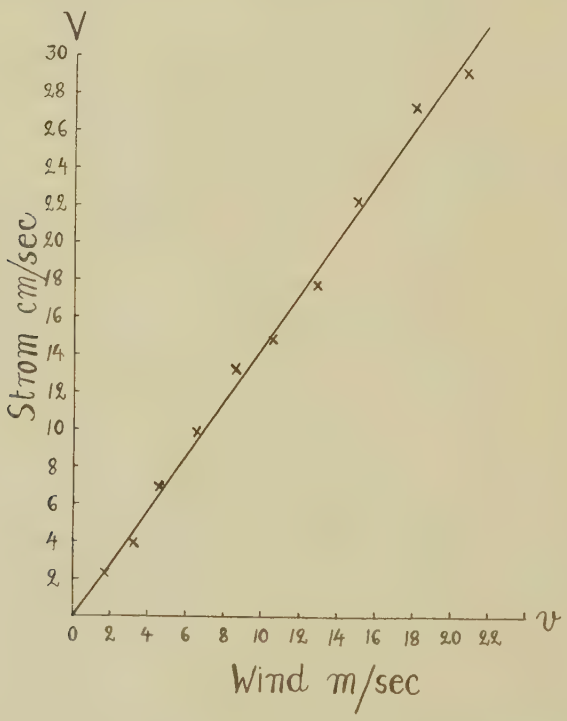

Fig. 3. Beziehung zwischen Wind- und Stromgeschwindigkeit.

delten Material mit einem gewissen Windstau zu rechnen hat, durch dessen Eliminierung sich ein etwas grösserer Wert für $\lambda\sqrt{\sin\varphi}$ ergeben würde[1]).

Um die hier benutzte Methode der Bestimmung des reinen Triftstromes zu verdeutlichen, ist in Fig. 4 die Eliminierung des Reststromes und des Staustromes graphisch für die Winde E 5 Beauf. und S 5 Beauf. dargestellt worden. Die Vektoren T_1, T_2 und T bezeichnen den ersten rohen

[1]) Bei Abnahme der inneren Reibung und der Dichte des Wassers muss der Wert der Konstante $\lambda\sqrt{\sin\varphi}$ zunehmen. Es ist sehr wahrscheinlich, dass man mit Beachtung der kräftigen Schichtung des Ostseewassers hier mit viel kleineren Werten des Koeffizienten der inneren Reibung als in den Weltmeeren zu rechnen hat, wodurch die Abweichungen von den THORADEschen Werten natürlich erscheinen. Die Abweichung der Dichte hat dagegen sehr geringe Bedeutung.

Windstrom, den vom Reststrom getrennten Windstrom und schliesslich den reinen Triftstrom. R ist der Reststrom und S der Staustrom, wobei R aus Tab. 1 und S aus Tab. 6 genommen wird.

Für den Tiefenstrom (in 20 m Tiefe) wurde eine Eliminierung des Staustromes nicht versucht, da die Richtung und Geschwindigkeit des Staustromes bei dem Abstand 3 m vom Meeresboden nicht leicht zu berechnen ist. Weiter wurde bei der Berechnung des Triftstromes die Einwirkung des internen Solenoidfeldes gar nicht beachtet, was besonders für den Tiefenstrom von Bedeutung sein kann. Sowohl die Ablenkung

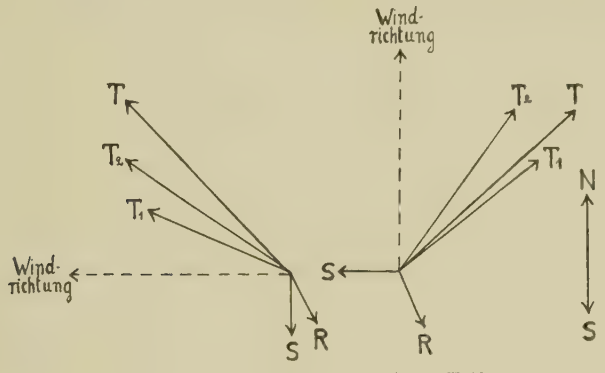

Fig. 4. Graphische Bestimmung des reinen Triftstromes.

wie die Geschwindigkeit des Oberflächenstromes steht in sehr guter Übereinstimmung mit der Triftstromtheorie von Ekman; hierbei ist besonders die lineare Beziehung zwischen Wind- und Stromgeschwindigkeit zu beachten (vgl. Fig. 3).

5. Die winderzeugte Strömung bei anderen Feuerschiffen.

Aus der früher zitierten Untersuchung von Witting (Annal. d. Hydrogr. 1909) und aus späteren von mir ausgeführten Zusammenstellungen der Strombeobachtungen bei den Feuerschiffen Äransgrund im Finnischen Meerbusen und Nahkiainen in der Bottenwiek geht hervor, dass die Beziehung zwischen Wind und Oberflächenstrom an den verschiedenen Feuerschiffen nicht dieselbe ist. Schon früher (S. 2) wurde hervorgehoben, dass die Stationsorte der anderen Feuerschiffe in der Ostsee einen viel kräftigeren Küsteneinfluss als bei Finngrundet voraussetzen. Es ist daher auch nicht möglich, diesen anderen Strombeobachtungen denselben Wert für eine Nachprüfung der Triftstromtheorie zu geben. Zwar wäre es unter gewissen Bedingungen theoretisch möglich, die Küstenstörung zu eliminieren, aber die Endergebnisse müssen natürlich um so unsicherer werden, je kräftiger im Verhältnis zum reinen Triftstrom die

Störungen sind. Dies gilt besonders für Untersuchungen der Drehung des Triftstromes mit wachsendem Abstand von der Meeresoberfläche. Eine solche Drehung wäre daher wohl kaum aus den Strombeobachtungen an den anderen Feuerschiffen einwandfrei festzustellen.

Was die Beziehung zwischen Wind und Stromgeschwindigkeit an der Oberfläche betrifft, so geht schon aus der Untersuchung Wittings hervor, dass die Beziehung an den meisten Feuerschiffen nicht eine lineare, sondern mit grösserer Wahrscheinlichkeit eine quadratische ist. Witting verwendete jedoch eine andere Reduktionsskala als die hier benutzte Köppensche für die Umrechnung von Beaufort in m/sec. Bei Umrechnung mittels der Köppenschen Skala, welche den wirklichen Verhältnissen an den Feuerschiffen besser entsprechen dürfte, verändert sich zwar die abgeleitete empirische Beziehung, aber doch nicht so viel, dass man eine lineare Beziehung erhielte. Entsprechende Ergebnisse hat auch J. P. Jacobsen für dänische Feuerschiffe gefunden.

Schliesslich sei noch bemerkt, dass eine exakte Bestimmung der Beziehung zwischen Wind und Strom eine genauere Definition des Begriffes Windgeschwindigkeit voraussetzt. Man müsste vor allem die Windgeschwindigkeit genau über der Meeresoberfläche messen, oder wenigstens eine mittlere empirische Beziehung zwischen Windgeschwindigkeit in der gewöhnlichen Beobachtungshöhe und an der Meeresoberfläche bestimmen.

English summary.

By calculating the vector means of the current for different winds a first relation is obtained between wind and current, at the surface and at 20 metres depth, at the Swedish lightship "Finngrundet" in the Bothnian Sea (Fig. 1). All current measurements made during the years 1923-27 are made use of. The current corresponding to a given wind, thus calculated, is the resultant of the pure drift current, the "slope current" (gradient current) caused by the influence of the wind on the inclination of the surface of a limited sea (in this case the Bothnian Sea) and the "characteristic residual current" brought on by the horizontal circulation in the Bothnian Sea (table 1). By elimination of the slope current and the residual current (S and R in fig. 4) the pure drift current T is calculated. This shows at the surface a mean deviation of about 43—45° to the right from the direction of the wind (table 6); the deviation is greater for weak winds (40°—53°) than for strong ones (24°—47°). The velocity of the surface current is directly proportional to the velocity of the wind. The ratio has the mean value of $1.44 \cdot 10^{-2}$, which agrees well with earlier determinations.

From the surface to 20 metres depth the deviation from wind direction increases by 19°. However, in calculating the current at 20 metres depth the influence of the slope current was not taken into consideration.

The results are, on the whole, in good agreement with the theory of V. W. Ekman, but the great velocity of the current at 20 metres depth (tables 2—4), about 3 metres from the bottom, is not in accordance with the assumption of the original theory, that the coefficient of eddy viscosity is independent of distance from the surface.

It was shown that conditions at the other lightships in the North Baltic Seas are less suitable for an investigation of the drift currents.

On the Aeration of the Bottom Waters through vertical Circulation.

By

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Whilst engaged on the quantitative evaluation of the bottom fauna in the White, Barents and Kara Seas, we were struck by the very uneven distribution of the bottom population in the open part of the sea. On the average there were less than 20 gr. (alcohol weight) of benthos organisms per sq. m. for the central part of the White Sea, as well as for all the northern part of the Barents Sea, and 50 gr. for the Kara Sea. In the southern part of the Barents Sea, in certain regions (like that of Petchora for instance), the average weight of the benthos rises to 500 gr. per sq. m.[1]) M. Idelson's[2]) analyses show that the variation in density of the bottom population is due to several factors. Among them depth, temperature, distribution of nutritive matter, nature of the soil, and chemical conditions (chiefly gaseous) in the bottom layer where the benthos lives are the most important.

Considering the last factor, we at once encounter the phenomenon of vertical circulation, which in the first place removes from the bottom

[1]) Zenkewitch, L. Materialien zur quantitativen Untersuchungen der Bodenfauna des Barents und des Weissen Meeres. Berichte des Wissensch. Meeresinstitutes Bd. II Lief. 4. 1927.

Zenkewitch, L., Brotzky, W., and Idelson, M. Materials for the study of the Productivity of the Sea Bottom in the White, Barents and Kara Seas. Journal du Conseil. Vol. III, No. 3, 1928.

Idelson, M. On the Nourishment of the Food Fishes in the Barents Sea. The Russian Hydrobiological Journal, Vol. VIII No. 10-11 1929.

[2]) Idelson, M. Distribution of the biomass of the bottom fauna in the Southern Barents-Sea. Transactions of the Oceanographical Institute (in press).

layer the different substances accumulating there, and secondly supplies this layer with materials, especially oxygen, from the upper horizons. On this account the researches of N. Subow in which he gives a method for obtaining a mathematical expression for the limit and for the intensity of vertical circulation are of very great interest.

We consider it necessary to explain briefly Subow's method. At about the moment when, under the influence of the winter vertical circulation, the intermixing of the layers reaches the bottom, it is to be observed that the salinity, temperature and specific volume are identical from the surface down to the bottom. Sometimes equal salinity and density of the entire water column can be attained only as a result of particular temperature conditions in the surface layer. If we know the average salinity and temperature of the entire water column at the moment when a unique specific weight becomes established from the surface to the bottom, we can calculate the number of calories which must be given out before that specific volume can be reached. This quantity N. Subow calls Q_t. In some cases, however, even if the temperature falls to freezing point, the vertical circulation does not reach the bottom (if, for instance, there exists a considerable difference of salinity between the surface layers and those near the bottom). In those circumstances, only a complementary formation of ice, by increasing the salinity of the upper water layers, can bring the vertical circulation to the very bottom. The number of calories needed for this complementary process, N. Subow terms Q_i. Having worked out the material in hand according to this method I introduced the additional quantity Q_τ, that is, the number of calories which must be given up by the water column for it to reach freezing temperature; this was calculated for all the stations. (For the Barents Sea it is, on an average, 1.8°).

Next, the values of $Q_\tau - Q_t$ were calculated for the stations not requiring the formation of ice for the circulation to be complete, and the +ve sign was attached to them. For the stations demanding the formation of ice the values $Q_\tau + Q_i - Q_t$ were determined, and the —ve sign was attached to them. Having charted all the indices thus obtained, the isolines: +100, +50, +25, ±0, —25, —50 and —100 were drawn.

The first chart summarises the data for the years 1921 to 1928, almost all the data belonging exclusively to August and September. The second chart presents the results obtained from the data from the expedition of the "Poseidon" and "Persej" for 1927 only; in this year we made only 130 stations (70 for "Poseidon" and 60 for "Persej").

[1]) Subow N. On the ventilation of the sea bottom waters. Exploration des Mers d'U.R.S.S. Fasc. 12, 1930.

These charts show that in the Kara Sea the vertical circulation can barely reach the bottom; to the east of the isoline 100 this circulation can only reach the bottom on condition that a powerful ice layer, 5—15 m. thick, is formed. Moreover, in the western part of the Barents Sea also, in spite of seemingly favourable indices, the vertical circulation is feebly expressed owing to insufficient cooling in winter. The most favourable regions for vertical circulation are situated on both sides of the zero isoline, between +25 and —25. The most productive regions of the Barents Sea, as well as the chief fishing regions, belong, as shown on chart 1 (shaded areas), to this neighbourhood. We regret not having had at our disposal the meteorological material which might have enabled us to estimate the quantity of heat given out by the sea surface during

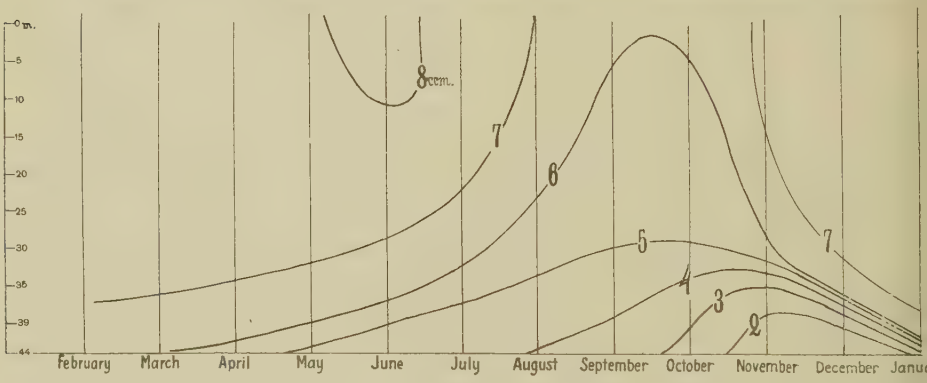

Fig. 1.

the winter in different parts of the Barents and Kara Seas. Because of this our charts are to a considerable extent blind.

Unhappily, we do not so far possess any direct observations as to the *seasonal course*, in our northern seas, of any hydrological character from the surface to the bottom, so as to determine the intensity and the yearly course of vertical circulation. It is needless to say how very necessary and important such data are for a correct understanding of the hydrology of our northern seas, where the ice formation process enters the arena as an exceptionally powerful factor.

Up to the present this particular feature in the regimen of the polar basins has not been given its due measure of importance. The unique material at our disposal is furnished by the work of the Murman scientific-industrial expedition in Ekatereninsky harbour (Bay of Kola) in 1904—6. A compendium of this material is given by K. Derjugin in his well-known paper[1]). Though it is true that this material is incomplete and is

[1]) Derjugin, K. Fauna des Kola-fjord und ihre Existenzbedingungen. Mémoires de l'academie imperial des Sciences de Petrograd VIII Série vol. 34, N. 1, 1915.

Chart No. 1.

spread over a period of 3 years, nevertheless the picture it presents is so vivid that we take the liberty of reproducing it in a slightly abridged form.

Depth in metres	16-II 1906	14-IV 1904	2-VI 1906	15-VIII 1904	4-VIII 1904	17-IX 1904	28-XI 1905	25-XI 1906	27-XII 1905
0	7.40	7.60	8.23	..	6.92	6.05	6.78	6.73	6.97
25	7.28	..	7.66	..	6.56	..	6.48	6.60	6.51
30	7.25	..	6.84	5.69	5.74	3.17	5.93	5.71	6.00
35	7.16	..	6.29	..	4.93	..	2.60	2.60	6.72
39	..	..	..	..	4.32	..	..	..	..
40	..	..	5.72	4.44	..	..	1.79	2.03	2.14
41	..	..	..	..	..	3.39	..	..	..
42	6.25	..	3.99	..	..	..	..	..	1.89
44	..	..	..	..	..	..	..	1.10	..

Chart No. 2.

Fig. 1 represents the same data in the form of isolines. We see that in September and October, with the advent of a vigourous cooling of the superficial layer, vertical circulation begins, extending during November, December and January to deeper and deeper layers and apparently reaching the bottom towards the end of January or beginning of February. About this time we have the complete intermixing of the entire water column. Evidently, in those years when ice forms on the surface of Ekaterininsky harbour the process has a particularly violent and sharp character. The end of February marks the onset of stagnation, and, at the time when vertical circulation from the surface begins (Sept., Oct.), there rapidly develops in the bottom layer an oxygen deficit with all the accompanying phenomena, and the quantity of oxygen falls almost to

zero. During this period (I—XII), at a short distance from the bottom, over a depth of 5 m. (36—41) there is a fall of oxygen content from 6 to 2 cm.^{3} per litre. In November the gas conditions are the most unfavourable for the bottom population.

It is most likely that, at this time, oxygen disappears completely close to the very bottom, and if in the preceding months, when the oxygen conditions of the bottom were more favourable, larvae of different invertebrates should settle and develop there, in the last months of the year all the bottom animal population in the deepest parts of the harbour would perish, and in this case we should experience the seasonal dying down of the young bottom fauna.

To what extent can these data for Ekaterininsky harbour be applied to the understanding of the hydrological regimen in the Barents and White Seas? It seems to us that they can be made use of, especially for the White Sea.

In Ekaterininsky harbour there is a fairly deep depression in the middle, and a comparatively shallow passage uniting the harbour and the Bay of Kola (the greatest depth of the depression is 47 m., the least in the passage 12 m.). In the White Sea likewise, we have, as well as at its greatest depths of 400 m. in the bay of Kandalaksha, comparatively small ones in the straits (40—100 m.). It is true that the White Sea is an extensive basin, but this cannot fundamentally so alter the regimen of this sea, as to make impossible the comparison with a smaller water basin, characterised by the same type of relief in the depression it occupies.

On the whole, the hydrological regimen, in its yearly course, must have many traits in common in all the water-basins of such a type.

When we gave the results of a quantitative evaluation of the bottom population of the White Sea, in the papers already mentioned, we endeavoured to find an explanation for the fact that the benthos is so exceptionally scanty in the middle part of the White Sea.

We could give no other explanation of this scarcity except the peculiar nature of the chemical regimen (chiefly the gaseous) in the bottom water-layer, to describe which, we regret to say, the data are so far still lacking.

Making use of the data furnished by two large expeditions in the White Sea, that of C. M. Derjugin in 1922—23, and of our Institute in 1926, it seems as if we have obtained nothing to prove the accuracy of our suppositions. Both the expeditions found, in their so-called "bottom" samples, a quantity of oxygen completely ample for the development of the bottom fauna. It is, however, necessary to draw attention to the following points.

1. The expeditions of C. Derjugin took place in August, that of the Oceanographical Institute in June, that is, at a season when, as in Ekateriningsky harbour likewise, the oxygen conditions in the deepest layers are still sufficiently favourable. These data cannot in any measure characterize the oxygen conditions of the deepest layers in the open sea during the succeeding months.

2. As C. Derjugin[1]) himself points out, he only took an insignificant number of series of oxygen samples and those at a certain distance from the bottom. The "Persej" expedition reached deeper layers, but its work fell into a still earlier time of year.

We must not forget that in the layer of water immediately contiguous to the bottom (which will be spoken of further), and which has remained absolutely untouched both by the work of C. Derjugin and by the so-called "bottom samples" of the "Persej", processes may take place about which as yet we have scarcely any idea. C. Derjugin himself remarks that it would be of the greatest interest to take samples close to the very bottom.

We cannot agree with the opinion of C. Derjugin (loc. cit.), 1) that in the White Sea there is generally a good aeration of the waters, 2) that the convection in the waters of the White Sea only embraces a superficial layer of 50 m. and 3) that the aeration of the depths takes place "in consequence of horizontal currents, which even in the abyssal parts of the basin, apparently are of a sufficiently intense character".

We suppose that, so far, we can be sure of the good aeration of the White Sea waters, the bottom layers excluded, only for a comparatively small part of the year. The same can be said as regards the convection in the White Sea waters. Of course, in summer, when the autumn stagnation begins to develop, the vertical circulation cannot extend through a great depth of water. We suppose, on the other hand, that in autumn and winter the vertical circulation in the White Sea must assume, especially when the ice begins to form, an excessively vigorous character. The complete picture of the cycle of events in this water-basin is exceedingly interesting and immensely important, and if we do not understand it our ideas as to the regimen obtaining in the White Sea will remain of a most superficial nature. We cannot therefore accept the opinion of C. Derjugin that the aeration of the depths in the White Sea takes place because of the horizontal currents. It is true that in our paper mentioned above (1925) we also were inclined to seek an explanation for the absence of stagnation in the Kandalaksha hollow in horizontal displacements of the

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[1]) Derjugin, K. Fauna des Weissen Meeres und ihre Existenzbedingungen. Explorations des mers d. U. R. S. S. Fasc. 7—8, 1928.

water, but now we yield the foremost place to vertical circulation. Exceedingly instructive are, we consider, MARJUTIN's[1]) data for Tcheskaya bay, where he established the existence of homohalinity in winter with a salinity of 36 $^0/_{00}$. In other words, in Tcheskaya bay, soon after the powerful formation of ice which takes place there has begun, there arises an active vertical circulation with an ever increasing salinity (a result of the water in the upper layers freezing out). It is known that the process of ice formation in the White Sea has a very vigorous course, leading to a marked increase of salinity in the surface waters. If the salinity is increased above 30 $^0/_{00}$, we experience a circulation which reaches the bottom.

This increase in salinity need not necessarily extend over the whole sea surface; it will be sufficient if it takes place in differents parts of the sea. In the same way as F. NANSEN supposes it possible for the salinity of the bottom layers of the sea to be increased at the expense of the mass of superficial water, of which the salinity has been raised by the freezing out of the surface water in winter and which flows down the slopes into the depths, so it can also be supposed that there is an influx of salter water into the depths of the Kandalaksha hollow from more shallow parts of the sea, as a result of great masses of water becoming transformed to ice.

If the case is really so, the phenomenon which interests us appears in the following light. When autumn cold comes on, and particularly when the powerful ice formation of winter begins, a vigorous vertical circulation begins in the White Sea, spreading to deeper and deeper water-layers. At the same time, in the bottom layer, stagnation develops from the autumn months on until January, and in some places February, its culminating point. (Stagnation ought here to be at a maximum very much later than in Ekatерininsky harbour, because of the great difference of salinity between the upper and the deepest water-layers). It is just at this period that the bottom fauna must experience a considerable diminution, and very possibly, perhaps not every year, even a dying off. In January—February the waters of the White Sea must become entirely or partly intermixed and enriched in oxygen to the very bottom. From the moment the ice begins to thaw and the spring floods to flow from the shores convection ceases and stagnation begins gradually to take place.

Owing to the excessive paucity of the population in the deepest waters and on the bottom of the White Sea, the development of stagnation pro-

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[1]) MARJUTIN. The hydrological régime of the gulf of Indiga. Proceedings of the First Russian Hydrological Congress. 1924. (1925.)

ceeds slowly, but reaches to a very high degree, which is certainly the explanation of the poorness of the bottom population. As in every semi-enclosed water-basin there must be in the White Sea very considerable variations in the cycle of events from year to year. Therefore in order to understand the hydrological regimen of this amazingly interesting and, of its kind, unique water-basin it is necessary to have:

1. Seasonal observations throughout the year and
2. Control observations in the most characteristic seasons of the year over a course of years.

Turning now to the Barents and Kara Seas, while we are certainly not likely to discover phenomena as powerful as those taking place in the White Sea, nevertheless in those depressions which are presented by the bottom relief of the Barents and Kara Seas, processes may occur of less activity, but analogous in all the details relatively to those we have found in the White Sea, especially where we find regions with a small population living on brown mud in more or less circumscribed hollows. If we likewise take into consideration the fact that owing to causes easy to understand there are, above these hollows, powerful cyclonic whirls in the water it can quite well be supposed that there exist in their central, deeper parts conditions favouring the development of stagnation with all the accompanying phenomena.

The whole phenomenon of vertical circulation acquires a particular interest for us biologists, if we endeavour to probe into those peculiar conditions which without any doubt reign in the bottom layer of water, having a depth of 1—2 m., in which the bottom population actually lives.

We must admit that up to this time the physico-chemical properties of the sub-bottom layer still remain completely uninvestigated.

In the State Oceanographic Institute, among different specialists, the urgency is continually being raised of the need for studying this problem in all its bearings; and the conviction exists that, for comparatively shallow water-basins, it is almost impossible to approach the problem of metabolism without knowing anything about the essential processes taking place near or on the bottom. This interests equally the biologist, the hydrochemist and the geomineralogist.

The peculiar chemical character of the bottom layer is due to the vital activity of the fauna and flora inhabiting the bottom and the soil, and to the processes going on in the soil itself. The importance of this problem in oceanography has been pointed out forcibly enough by W. Boutke-

VITCH[1]) and N. SUBOW[2]) and lastly by the author of the present paper. Difficulties of a technical nature stood, and still stand, in the way of an investigation of the physico-chemical properties of the bottom layer. Up to the present, we have had no instrument for taking sufficiently perfect samples of water from the bottom. The water bottles of the usual type furnish us at best with a sample of water from a layer 3 to 5 m. off the bottom, and, furthermore, in going down they produce a considerable intermixing of the layers through which they pass. The ideal instrument which would fulfill the requirements must posses the three following qualities.

1. Whilst being lowered, it must produce a minimal intermixing of the water.
2. The instrument must operate the instant it touches the bottom.
3. The instrument must indicate the natural stratification existing near the bottom or else record exactly the distance from the bottom at which the sample was taken.

The author tried on his own account to construct an instrument answering to these three requirements. At his request Prof. M. KNUDSEN also constructed a special bottom-water sampler. These instruments are now being tested. At the same time, the hydrochemical section of the Oceanographic Institute is carrying on continuous seasonal observations of the bottom layer in Ekaterininsky harbour by means of a special apparatus which, though not adapted for work during expeditions, appears to give faultless results in an enclosed and not very deep harbour. Data for the bottom layer are accumulating gradually and will be published shortly.

The object of the present paper is to raise and examine several questions of a general character.

We are perfectly justified in presupposing the existence of very sharp stratification in the layer of water contiguous to the bottom.

There are some direct indications of this in the literature, though, for the most part, the accuracy of the method leaves something to be desired. MURRAY and IRVIN[3]) have noted the sharp diminution of dissolved manganous carbonate in the water as the distance from the soil increases.

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[1]) BUTKEWITSCH, W. Die Bildung der Eisenmangan-Ablagerungen am Meeresboden und die daran beteiligten Mikroorganismen. Berichte des Wissensch. Meeresinstituts. Bd. III, Lief. 3, 1928.

[2]) SUBOW, N. loc. cit.

[3]) MURRAY and IRVIN. Transact. of the R. Society of Edinburgh. 35. 1894.

It is not clear what method was followed by the authors. If they took for their analysis the water from the ground tube, their data lie open to doubt. Interesting data are furnished by the researches of J. Bruce[1]) and H. Moore[2]).

Of great interest also for the question we are examining are the data in the work of W. Boutkevitch already mentioned (l. c.). The author quotes the opinion of renowned specialists upon ferro-bacteria (H. Molisch, N. Cholodny and others), who remark that, up to now, no ferro-bacteria have been discovered in the sea, and who seem, indeed, doubtful of their existence in the sea at all, as sea water possesses chemical properties which deprive the ferro-bacteria of favourable conditions for their development. The ferro-bacteria "are not capable of bearing high concentrations of mineral salts", and further, "in the sea water, presenting as we know a feebly alkaline reaction (pH 7.8—8.3), the dissolved ferrous carbonate indispensable for the ferro-bacteria must naturally be lacking".

Admitting the weight of Cholodny's considerations, who considers sea-water an unfavourable medium for the development of ferro-bacteria, W. Boutkevitch quite rightly points out that "in the regions close to the sea bottom . . . under the influence of the processes going on in the bottom deposits, the chemical state of the water can undergo certain alterations, and thus deviate more or less from its normal state".

These deviations can manifest themselves especially in a higher concentration of hydrogen ions, at the expense of the carbonic acid given out by the bottom deposits and, in conjunction with this, in an increased capacity of the manganous and ferrous oxide to remain in solution.

In the stagnation period, especially at the beginning of winter and in the regions of the sea where the bottom relief is suitable, the specific peculiarities of the chemical state of the bottom layer attain their maximum realisation, while with the development of the vertical circulation, if the convection currents reach the very bottom, these specific peculiarities disappear. Sharp disturbances must be correspondingly produced in the activity of the bottom population, animal as well as vegetable. To one group of organisms vertical circulation brings more favourable conditions of existence, for another it creates a medium unfavourable to development; for a time, until the next period of stagnation comes, their final develop-

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[1]) Bruce, J. R. Physical Factors on the Sandy Beach. Journ. of the Mar. Biol. Assoc. Vol. XV. No. 2, 1928.

[2]) Moore, H. B. The Muds of the Clyde Sea Area. Journ. of the Mar. Biol. Assoc. Vol. XVI. No. 2, 1930.

ment becomes impossible, such as must be the case especially with the ferro-bacteria. It appears certain to us that, for the wide regions of our northern seas, with their shallowness, the processes going on in the layer close to the bottom must have a seasonal character. Most likely, the coarse concentric stratification of the ferro-maganese concretions so characteristic of certain regions in the northern seas, and by no means typical for ferro-manganese concretions in general, can be taken as evidence of the yearly recurrence of such cycles. Such a cyclic, seasonal recurrence in the chemical state of the bottom layer must be especially striking in those regions where the bottom relief presents depressions and where in winter a heavy ice layer is formed. First among such regions are the White Sea, the northern part of the Barents Sea and the Kara Sea. It is just in these regions that we find an insignificantly small benthos, due to an accumulation in the bottom layer of carbonic acid and a lack of oxygen at the time of the autumn stagnation; it is just here that stratified concretions originate (indicated on chart 1 by small circles).

The most accentuated concentrical stratification of concretions is encountered in the White Sea, the northern part of the Barents Sea and in the Kara Sea; in other words, in those regions in which one can suppose the existence of a distinct stagnation in autumn and of a vigorous vertical circulation in winter. During the period of aeration of the layer close to the bottom, there is a pause in the vital activity of the ferro-bacteria, which begins afresh as stagnation develops.

One can thus see clearly that:

1) The ferro-manganese concretions with coarse stratifications are found, in our northern seas, in those regions where more or less prolonged periods of stagnation exist near the bottom during which periods alone the ferro-bacteria can find conditions suitable for their development.

2) In the regions where a very strongly marked period of stagnation in the bottom layer is succeeded by a period of good aeration, we discover concretions constituted by several coarse concentric strata. It is true that the fractures of concretions from great depths (Murray) present a stratified structure also, but it is of a different order. In our case we have to do with the minutely stratified structure which characterizes the periodicity of many biological phenomena. The stratification we speak of, in considering our northern seas, presents coarse stratified structures, and can itself include many strata of the first type. In the same way the scales of fishes exhibit, in addition to a minute stratification, winter and summer rings — strata of a secondary order.

The peculiar processes taking place in the bottom layer, which can extend with favourable conditions through a more or less great range of water in the depths, cannot but have as well an immense influence upon the water layers situated above, when the winter vertical circulation produces an intermixing of the entire depth of the waters. And it may be that in no other single water-basin can this be of as great importance as in our Barents Sea.

When convection is most active the bottom layers become enriched in oxygen; the carbonic acid accumulated during the period of stagnation is carried off, and the upper horizons acquire quantities of nitrogen and phosphorus compounds, all of which leads to an exceptionally vigorous vernal development of the phytoplankton in our northern seas. The importance of the nearness of the bottom (in the presence of a vertical circulation) as a factor promoting an abundance of plankton in the upper horizons has been duly pointed out by K. BRANDT[1]) in his latest works. The biological significance of vertical circulation in sea basins was first put forward on very good grounds by A. NATHANSOHN[2]), as long as 20 years ago. For fresh water basins this had been done ten years earlier. These last years, much that is valuable for the study of this problem has also been contributed by K. BRANDT, at first an adversary of NATHANSOHN's theory. The immense importance of vertical circulation as a factor of biological significance has likewise been shown through the brilliant researches of the "Meteor" expedition[3]).

It is a great pity that with us, in the north, investigators have approached this question only recently, in the last two or three years. The researches of SUBOW already mentioned contain, as it appears to me, a great deal for the further development of the entire problem and for a correct approach to the study of the circulation of material in our northern seas. Also, it is of essential importance to recognise fully that, without

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[1]) BRANDT, K. Phosphate und Stickstoffverbindungen als Minimumstoffe für die Produktion im Meere. Rapp. et Procès-Verbaux des Réunions. Vol. LIII, 1929.

[2]) NATHANSON, A. Verticale Wasserbewegung und quantitative Verteilung des Planktons im Meere. Ann. d. Hydr. u. Marit. Met. 1906.

NATHANSOHN, A. Über die Allgemeinen Produktionsbedingungen im Meere. Intern. Revue d. g. H. und H. Bd. I, 1908.

[3]) HENTSCHEL, E. und WATTENBERG, H. Plankton und Phosphat in der Oberflächenschicht des Südatlantischen Ozeans. Ann. d. Hydr. u. s. w. Bd. LVIII Hf. 8, 1930.

BÖHNECKE, S., HENTSCHEL, E. und WATTENBERG, H. Über die hydrographischen, chemischen und biologischen Verhältnisse an der Meeresoberfläche zwischen Island und Grönland. Ibidem Hf. 7, 1930.

WATTENBERG, H. Die Deutsche Atlantische Expedition. Berichte über die chemischen Arbeiten. Zeitschr. d. Ges. f. Erdkunde, 1926—27.

data on the annual course of the different processes going on in the layer close to the bottom, our ideas as to the circulation of materials will never be of a conclusive nature and that therefore most serious attention must be given to the study of that wonderful laboratory, the sea bottom. We must admit that in the general picture of the biochemical processes in our northern seas (this of course is applicable to other seas as well), one must distinguish the following vertical zones.

I. *Oxidization zone.*
   1. Subzone. Water enriched by Oxygen (through photosynthesis and by gas exchange with the atmosphere) 0 to 100 m depth.
   2. Subzone. Insignificant consumption of Oxygen (Zooplankton). Depth more than 100 m.

II. *Oxidization-reduction zone.* (Bottom layer in the strict sense.)
   1. Subzone. Considerable consumption of Oxygen, up to its complete utilization.
   2. Subzone. Unstable condition, having usually a seasonal course and depending on the chemical nature of the soil.

III. *Reduction zone.* Upper soil layers inhabited by the bottom fauna and flora.

In the regions favourable to stagnation, the upper limit of the reduction zone, normally situated as much as several centimetres deep in the ground, can stretch beyond the ground in autumn and through the reduction processes extend the layer to several decimetres. In the most favourable cases the reduction zone can occupy a more extensive layer (as in the fjords and the Black Sea). In his detailed researches on the chemical nature of the waters in the Black Sea N. Tschigirin[1]) points out the necessity of contrasting (for the Black Sea) the upper oxidization zone (0—200 m) with the lower reduction one (deeper than 200 m). The vertical division of the sea zones, given above, has been worked out with the kind participation of N. Tschigirin.

To conclude, it is a pleasant duty to acknowledge that it is only owing to the friendly collaboration of N. N. Subow that I was able to work out some of the parts of this paper.

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[1]) Chigirin, N. (Tschigirine). Phosphorus in the Water of the Black Sea. Travaux de la Station biologique de Sébastopol. Vol. II. 1930.

Chigirin, N. et Danilcenko, P. De l'azote et ses composés dans la mer Noire. Ibidem.

Résumé.

En étudiant les matériaux recueillis en vue d'une évaluation quantitative de la faune des fonds, dans la mer de Barents, la mer Blanche, et la mer de Kara, nous avons établi que dans ces régions la densité du benthos a une distribution très inégale. Depuis 20 gr. par 1 m.² en moyenne dans la partie occidentale de la mer de Barents, on atteint à mesure qu'on avance vers l'est, des rayons où le benthos est considérablement plus dense, jusqu'à 500 gr. en moyenne par 1 m.², dans certaines sections du rayon de la Petchora. Toute la partie septentrionale de la mer de Barents et la partie centrale de la mer Blanche ont en moyenne, dans le benthos une densité de 20 gr. par 1 m². Pour la mer de Kara la moyenne est de 50 gr. par 1 m².

Parmi les facteurs desquels dépend la densité plus ou moins grande du benthos, l'aération de la couche d'eau du fond, qui se fait au moyen de la circulation verticale, a une grande importance. Utilisant les 220 stations du "Persej" (1921-28), et les 70 stations du "Poseidon" (1927), nous avons déterminé, par la méthode de Zubof (l. cit.), Q_t et Q_i pour chacune des stations, et ensuite, comme complément, la quantité Q_τ (où τ correspond à la température de congélation) a été déterminé pour toutes les stations, c'est à dire, le nombre de calories que doit perdre 1 cm.² de surface pour que toute la colonne d'eau atteigne la température de congélation. Si Q_τ est plus grand que Q_t, la station est déterminée par le nombre $Q_\tau - Q_t$ avec le signe +. Si Q_t est plus grand, la quantité $Q_t + Q_i - Q_\tau$ est déterminée avec le signe —. D'après les indices obtenus, on a tracé les isolignes sur les tables 1 (1921—1928) et 2 (1927).

Les conditions climatiques qui garantissent le dégagement de la chaleur par la surface de la mer, nécessaire pour qu'il y ait une bonne circulation verticale, se trouvent à peu près entre les isolignes de + 25 et — 25.

C'est à cette bande aussi qu'appartiennent les zones de la productivité la plus grande du plankton comme du benthos.

L'aération des couches d'eau du fond doit avoir un caractère saisonnier plus ou moins prononcé, et atteindre son maximum au moment du refroidissement et de la formation de la glace d'hiver. Ce cours saisonnier se voit d'une manière frappante sur la fig. 1, qui représente le cours annuel des isoxigènes dans le Ekaterininskij port (Baie de Kola).

Nous devons trouver un tableau analogue dans la mer Blanche, où la circulation verticale, devenant difficile en automne, ne contribue pas à un développement abondant de la faune du fond. Un phénomène de type

analogue, a lieu dans la partie septentrionale de la mer de Barents, et dans la mer de Kara.

Il n'existe dans l'outillage des recherches scientifiques d'océanographie, aucun apparail qui permette d'obtenir des échantillons de l'eau provenant de la couche directement contigüé au fond. Ceci nous empêche de faire actuellement des observations exactes sur le régime chimique de la couche d'eau la plus profonde.

Toute une serie de considérations nous fait supposer qu'il est possible que dans la couche d'eau contigüé au fond, il y ait une stratification d'oxygène très nette qui se développe d'habitude en automne, dans les régions présentant des conditions favorables.

Plusieurs circonstances indiquent qu'il en est ainsi. Au dépens de l'acide carbonique, dégagé par les organismes du benthos dans la couche d'eau du fond, la concentration des ions d'hydrogène s'élève, et il peut se former des oxydes de manganese et de fer en dissolution. C'est justement dans ces rayons là qu'on constate une grande extension de ferrobactéries dans le sol, ainsi que la présence de concrétions ferro-manganeuses. La grossière stratification (macro-stratification) des concrétions ferro-manganeuses, indique, selon l'avis de l'auteur, un cours saisonnier dans la stratification, et représente des couches annuelles.

Pendant la puissante convection hivernale, les couches du fond s'enrichissent en oxygène, l'acide carbonique accumulé pendant le temps de la stagnation est éloigné, les horizons supérieurs s'enrichissent de sels nutritifs que montent des fonds.

En se basant sur tous les matériaux étudiés l'auteur juge qu'on peut préciser davantage les schémas existants sur la division verticale des couches d'eau dans la mer, et propose le schéma suivant:

I. *Zone d'oxydation.*
   1. Subzone. Enrichissement mécanique en oxygène à la suite de l'agitation de la mer et des depôts atmosphériques.
   2. Subzone. Enrichissement en oxygéne par suite de la photosynthèse.
   3. Subzone. Utilisation d'oxygène en quantité insignifiante.

II. *Zone d'oxydation-réduction.*

   (Couche d'eau touchant le fond au sens strict du terme.)
   1. Subzone d'une utilisation considérable d'oxygène.
   2. Subzone d'un régime instable, à cours saisonnier nettement marqué, dépendant largement de l'état chimique du sol. (Zone de transition.)

III. *Zone de réduction.* Zone du sol même habituellement. Sa limite supérieure peut s'élever au dessus du sol. Dans la mer Noire cette zone comprend toute la profondeur de la mer de 150 à 200 mètres, sauf la couche supérieure.

1. Subzone. Couche d'eau immédiatement au dessus du sol.
2. Subzone. Couche d'eau à l'intérieur même du sol.

A New Speed Surface Sampler.

By

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The difficulties attending the collection of sea surface samples and temperatures on commercial vessels have been fully treated by J. R. Lumby in this Journal (Vol. II, p. 332, and Vol. III, p. 340). The excellent apparatus there described has, however, the disadvantage of being somewhat heavy and, as a result of this, it has not been possible to ensure that the observers on certain of the ships from which our Bureau obtains observations use it properly. In order to secure easier working I have tried to incorporate the essential idea of Mr. Lumby's apparatus in a smaller and lighter model of which the illustation will give a general impression. It consists of an outer bucket 26 by 7.5 cm, into which is inserted a funnel with a tube which opens into a small vessel intended to retain water round the bulbs of the two thermometres. These are attached to the tube by means of short pieces of rubber tubing at the upper end, and slings of rubber at the lower. The right hand thermometer shows temperatures from zero to 10°, the other from 9° to 20° C. The inset is not fastened by a bayonet-joint, which is a difficult mechanism to operate, but is secured by a screw to the bottom of the bucket. This screw finds its own way and it requires only two turns of the funnel to make the thing ready for use.

It is towed for 20 secs. and the temperature is read without lifting the inset more than necessary out of the bucket. It was tried by me on a ship moving 12 knots, in 2° of frost. Only after one minute exposure to the cold air did the reading change a tenth of a degree. The water sample is taken from a tap in the bottom of the bucket. The apparatus is made by Bergen Nautik, Bergen, and has been in use on two ships for about one year. The observers find it convenient.

A comparison of the Vigneron-Dahl Trawling Gear with the Steam Otter Trawl, in the Hake Fishery.

By

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In the early part of 1922, considerable interest was shewn by the British trawling industry in a new type of trawl which was then in course of adoption by the French trawling fleets, especially at La Rochelle. This net was said to be much superior in efficiency to the steam otter trawl (hereafter referred to as the S. O. T.) then in use in the English fleets, especially in the capture of hake, for which it was originally designed. It was said to be based on the "bull-net" or "filet-boeuf", a type of large net already in use, but of necessity towed between two steamers. By the new method, however, a net somewhat similar to the "bull-net" could be towed by a single trawler. The "V-D" or "French gear" is now too widely used and too well-known to need re-description here. A recent account of it, illustrated by excellent models prepared by the inventors, has been written by Le Gall (1).

In August, 1922, two trawlers at Plymouth were equipped with the new gear; by March, 1923, the Cardiff fleet was so equipped, and Swansea soon followed suit. During the period from February, 1923, to March, 1924, the English hake ports were actively fitting out their ships with the new gear, and, though there were set-backs, and though Fleetwood was somewhat conservative in its attitude, by the latter date the V. D. trawl was firmly established in the English hake fishery, and has been in almost universal use, though subjected to an infinity of variations and modifications, ever since.

During the period from February, 1923, to March, 1924, therefore, the old and the new types of gear were competing against each other.

The Fisheries Department of the Ministry of Agriculture and Fisheries collected data as to the landings of ships using the two types of gear, and this enables us to compare their respective performances during this period. Unluckily, the original records have been destroyed; nothing is now available except the extracted and combined results, which are set out in Tables I and II below.

These data do not distinguish the fish into species. They have been so combined and calculated as to shew, by months, the weight of fish (of all species) landed per 100 hours' fishing in the statistical regions West of Scotland, West of Ireland and South of Ireland, by ships fitted out with the V. D. and the S. O. T. respectively.

For the months of February, March and April, 1923, the data were not distinguished into regions. They are set out below, in Table I.

Table I.

Month	Number of Voyages		Landing of all species per 100 hours		Efficiency of V.D. compared with S.O.T.
	V.D.	S.O.T.	V. D.	S.O.T.	
1923 February .	4	22	191	186	V.D. Greater by 3%
March	3	22	360	239	V.D. Greater by 50%
April	7	29	323	157	V.D. Greater by 106%

The remaining data, in which the regions are distinguished, are set out in Table II.

In Column 1 of Table II is given the month and the year, in Column 2 the mean landing of hake per 100 hours' fishing in the regions and month concerned, and in Column 3 the percentage of hake in the total weight of demersal fish landed from the region concerned in that particular month. The data in Column 2 are taken from the writer's Natural History of the Hake, Parts I and II, Appendix Table V. (2). Those in Column 3 are calculated from data supplied by the Statistical Branch of the Fisheries Department.

In Columns 6 and 7 are given the mean landing, in cwts. per 100 hours' fishing, of all demersal fish caught by ships using the V. D. gear (Column 6) and S. O. T. (Column 7) respectively.

In Columns 4 and 5 are shewn the number of voyages on which the data in Columns 6 and 7 are based, and finally, in Column 8, the efficiency of the V. D. gear, as compared with the S. O. T. is shewn, based on the data in Columns 6 and 7.

Table II. A comparison of the efficiency of the V. D. gear (as compared with the S. O. T.) with the landings of hake and the percentage of hake in the total landing.

Month	Mean Landing of Hake per 100 Hours	Percent of Hake in Total Catch	Number of Voyages		Landing of all Species per 100 Hours		Efficiency of V.D. compared with S.O.T., based on 6 and 7	
			V.D.	S.O.T.	V.D.	S.O.T.		
1	2	3	4	5	6	7	8	
West of Scotland								
1923 Sept.	68	43.7	5	194	382	227	V.D. Greater by	68%
Oct.	70	42.6	18	203	270	183	—	48%
Nov.	69	39.0	29	170	227	201	—	13%
Dec.	47	27.3	27	161	196	201	— Less by	3%
1924 Jan.	9	6.0	7	147	203	218	—	7%
Feb.	9	4.4	12	177	296	268	— Greater by	10%
Mar.	(15)							
Average	45							21.5
West of Ireland								
1923 May	163	73.8	44	13	261	176	V.D. Greater by	48%
June	153	63.6	6	3	210	165	—	27%
July								
Aug.	159	78.6	45	16	231	168	—	37%
Sept.	125	64.3	55	13	191	147	—	30%
Oct.	129	57.0	87	8	227	172	—	32%
Nov.	104	47.0	49	7	219	155	—	41%
Dec.	147	52.8	20	4	321	203	—	58%
1924 Jan.	138	51.4	38	5	287	134	—	114%
Feb.	205	58.7	26	1	392	221	—	77%
Mar.	(153)							
Average	147							51.6
South of Ireland								
1923 May[1]	89	59.6	101	88	216	153	V.D. Greater by	41%
June[1]	110	61.8	112	121	232	159	—	46%
July[2]	121	69.5	50	50	240	143	—	68%
Aug.[2]	85	67.7	17	10	196	112	—	75%
Sept.[2]	59	68.7	16	9	184	137	—	34%
Oct.[2]	57	55.4	22	11	221	177	—	25%
Nov.[2]	54	37.9	43	79	223	166	—	34%
Dec.[2]	68	48.2	43	16	229	167	—	37%
1924 Jan.[1]	70	47.6	146	83	210	144	—	46%
Feb.[1]	82	56.9	146	69	232	203	—	14%
Mar.	(49)							
Average	79.5							42.0

[1]) Based on the data referring to the whole region.

[2]) Based on the data referring to the individual rectangles, excluding Rectangles XX_1 and XX_2, the Smalls herring trawling grounds.

Before proceeding to discuss the material before us, several remarks must be made. Firstly, the number of voyages (Columns 4 and 5) on which the data in Columns 6, 7 and 8 are calculated, shews great variation and often great disparity. Thus, for the region West of Scotland, the mean landing for ships fitted with the S. O. T. is based on a large number of voyages, that for ships fitted with the V. D. on comparatively few; the reverse is true of the region West of Ireland. Secondly, I have had to recalculate the data for the months from July to December, 1923, in the region South of Ireland, since the original data include the results of the Smalls herring-trawling fishery, which is a very intensive and peculiar fishery better eliminated from the present discussion, though, in this fishery, the S. O. T. appeared definitely to outfish the V. D. Thirdly, it is well known that the largest and most powerful trawlers were the first to be fitted out with the V.D. gear, and, in our comparison, some allowance may be made for this.

Fourthly, the first V. D. trawls used were of French manufacture, and some appear to have had a decidedly smaller mesh than the S. O. T. in use in the English fleets. (See also Postscript, second paragraph).

Lastly, we must clearly bear in mind that the data in Columns 6, 7 and 8 are based on landings of all demersal fish, whereas, in the discussion, we shall focus our attention upon the hake fishery.

Discussion.

The efficiency of the V. D. gear has been vaguely but enthusiastically assessed at twice or thrice that of the S. O. T. The superiority of the new gear is, of course, claimed by the inventors, and is said to be due, chiefly, to two factors. Firstly the gear has a much greater effective width than the S. O. T.; this is achieved by the long bridles (up to 100 fathoms in length) which connect the net to the trawl boards, and which, by stirring up the mud on the sea floor, drive the fish inwards towards the advancing net, and have, therefore, the effect of a net of enormous width. Secondly, the gear has a much greater sweep in height; this is attained by buoying up the headline with floats, the net being so designed as to enhance this effect.

The success of the V. D. trawl speaks for itself; this note is written because the writer, who is examining the statistics of the hake fishery, must take this innovation into account, and he must endeavour to distinguish the effect of its introduction from that of natural fluctuations in the hake stock.

A glance at Tables I and II will shew that the V. D. trawl enjoys no

constant superiority in performance over the S. O. T. Its efficiency, in fact, has varied between 114 % greater and 7 % less than that of the S. O. T. It is true that there may be little relation between the data for landing in unit time (Columns 6 and 7, Table II) and the percentage superiority of the V.D. gear over the S.O.T. (Column 8, Table II). For instance, in January, 1924, the landing per 100 hours' fishing was decidedly lower than in the months immediately before and after, yet the percentage superiority of the V. D. was much higher. But other factors, and especially climatic factors must be considered. Bad weather throughout any month would adversely affect ships using each type of gear, without necessarily affecting one more than the other.

The three months in Table I shew a rapidly increasing superiority in the performance of the V. D. gear, and this might perhaps be ascribed to an increase in technical efficiency. But a study of the later months reveals a different picture.

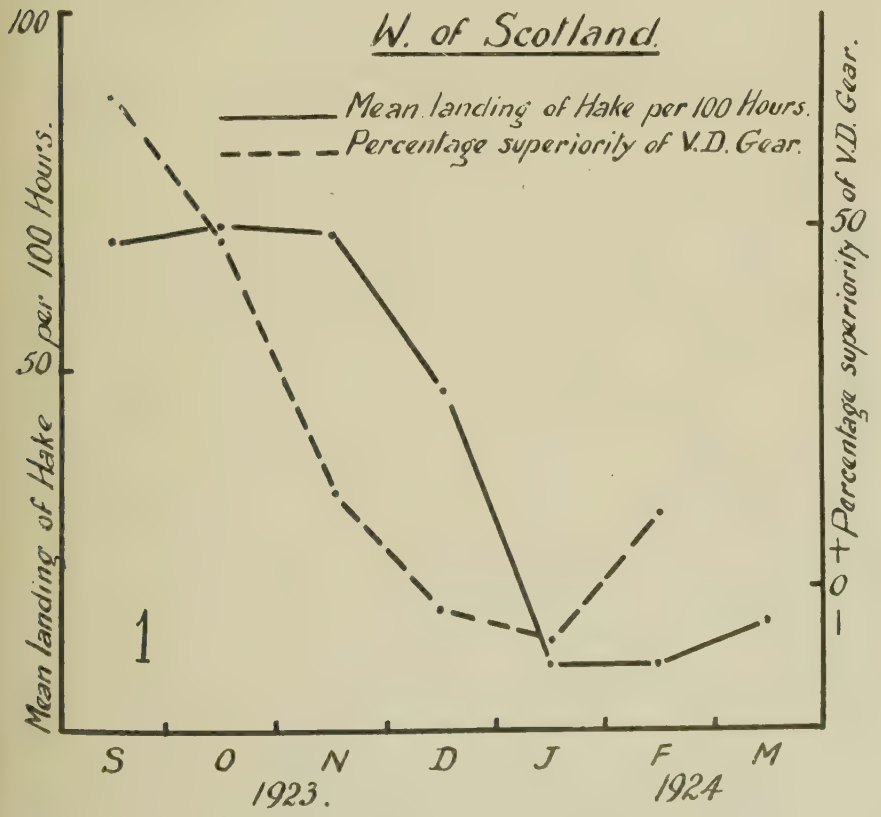

Fig. 1. Region West of Scotland. Comparison between the efficiency of the V. D. gear and the mean monthly landings of hake, per 100 hours' fishing.

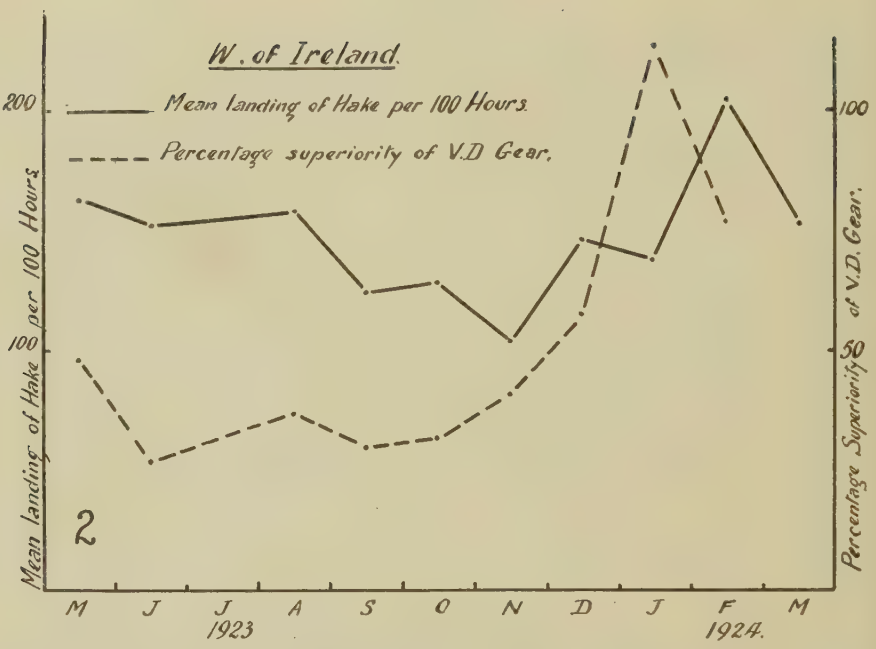

Fig. 2. Region West of Ireland. Comparison between the efficiency of the V. D. gear and the mean monthly landings of hake, per 100 hours' fishing.

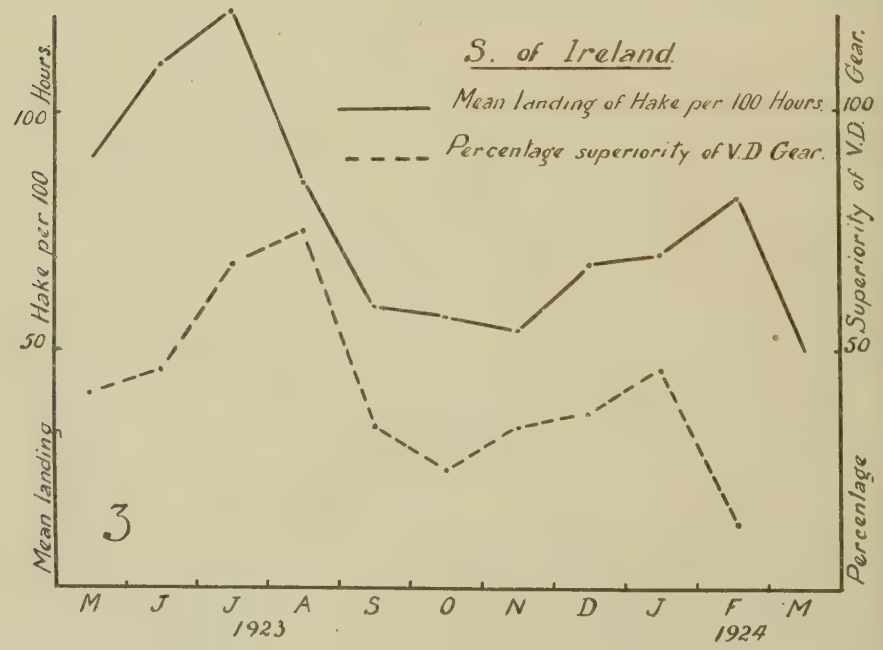

Fig. 3. Region South of Ireland. Comparison between the efficiency of the V. D. gear and the mean monthly landings of hake, per 100 hours' fishing.

In Figures 1, 2 and 3, the data in Table II are plotted graphically for the regions West of Scotland, West of Ireland, and South of Ireland respectively. The broken line represents, in all cases, the variation from month to month in the efficiency of the V. D. gear as compared with the S. O. T. (data in Column 8, Table II).

The variation in the relative efficiency of the V. D. gear is not haphazard, but forms strikingly regular curves in each region.

In the region West of Scotland, the relative efficiency of the V. D. falls from 68 % greater in September, 1923, to 7 % less in January, 1924, recovering to 10 % greater in February.

In the region West of Ireland, the relative efficiency of the V. D. fluctuates about 40 % greater from May, 1923, to October, 1923, when it increases to 114 % in January, 1924, falling to 77 % in February.

In the region South of Ireland, the relative efficiency of the V. D. increases from 44 % greater in May, 1923, to 75 % greater in August, 1923. Then there is a decline to 25 % greater in October, 1923, and then a recovery to 46 % greater in January, 1924, and finally, a fall to 14% greater in February, 1924.

It is quite clear that no technical factor is here involved. A biological factor at once suggests itself. The monthly variation in the superiority of the V. D. gear is similar to the mean monthly variation in the catch of hake. The continous lines in Figures 1, 2 and 3 join the points representing the mean monthly landing of hake, per 100 hours' fishing, in the appropriate regions and months (data in Column 2, Table II). The curves so obtained are closely similar to the curves representing the monthly variation in the relative efficiency of the V. D. gear. Though the shape of the two curves is so similar, their modes do not coincide, and, in Figure 1 and the latter part of the curves in Figures 2 and 3, there is a "lag" of about one month on the part of the mean landing, per 100 hours, of hake. It is as if the V. D. gear had anticipated the mean landing, in unit time, of hake in the whole area. The explanation may lie in this, that the larger ships, which were the first to carry the new gear, were working in deeper water, where the concentrations and dispersions of the hake are felt earlier than in the region as a whole. In the region South of Ireland, however, the peak in the curve for "percentage superiority of the V. D. gear", in August, is one month ahead of that in the curve for "mean landing of hake."

Finally, if the average monthly landing of hake, over the period of comparison, is compared with the average monthly superiority of the V. D. gear, in each region ("Averages", Table II) there is excellent agreement. Thus, the region West of Scotland has an average landing of hake

of 45 cwts. per 100 hours' fishing, and an average V. D. superiority of 21.5 %; the corresponding figures for the West of Ireland are 138 cwts. per 100 hours' fishing, and 52 %, and for the South of Ireland, 79.5 cwts. per 100 hours' fishing, and 41.6 %.

We are justified in thus comparing the mean landing of hake, with data as to relative performance based on the landings of all species, at least in the regions West of Ireland and South of Ireland, because, as may be seen in Column 3, Table II, hake is there the dominant species, usually comprising more than half the total landings from the region. In the region West of Scotland (and, less markedly, in the other regions) the percentage of hake in the landings corresponds with the landing of hake in unit time, and with the relative performance of the V. D.

Further, it cannot be argued that the performance of the V. D. trawl is associated with the fluctuations in the hake fishery because ships equipped with the V. D. gear were fishing largely for hake, while ships equipped with the S. O. T. were fishing largely for other species. In many cases the performance of the two types of gear in the same statistical rectangle (see EDSER, 6), in the same month, are separately given in the Ministry's statistics, though not inserted in Table II. These data, referring to much smaller units of area, shew the same relation between the relative performance of the two types of gear, and the landings of hake, as the much larger statistical regions given in Table II. I know of few statistical rectangles in which two separate fisheries may be prosecuted at the same time.

We are driven, then, to the surprising and perplexing conclusion that the performance of the V. D. trawl, as compared with the S. O. T., in the period dealt with, was dominated by the natural seasonal fluctuations in the hake fishery, and that the greater the landing of hake in unit time, i. e. the denser the concentration of the hake, the greater the superiority of the V. D. gear over the S. O. T. At low concentrations of hake we find little to choose between the two; indeed, on some cases the S. O. T. appears to have more than held its own, especially when it is remenbered that the most powerful trawlers were the first to be equipped with the new gear, and that the first V. D. nets appear to have had a smaller mesh than the S. O. T. then in use. In the rest of the discussion, we shall extend this conclusion, based on the seasonal fluctuation in the fishery, so as to apply to fluctuations in the fishery from year to year.

If the superior performance of the V. D. gear were due to a greater effective width, we should expect to find a fairly constant superiority in efficiency, just as, using GARSTANG's well-known analogy of a shovel

scooping marbles off a table, doubling the width of the shovel will roughly double the number of marbles taken at each scoop of the shovel (3). The fact that there does appear to be a residual superiority, if it is not due to a smaller mesh, may be due to this greater width.

A possible explanation of the seasonally-fluctuating performance of the V. D. gear may be found in the undoubtedly bathypelagic habits of the hake, as shewn, for example, by its diurnal vertical migrations, and by the nature of its food (2). We may imagine that the hake, even by day, does not lie actually on the bottom, but near it, that is, the hake shoal is distributed in height as well as in area. Therefore, the greater effective height of the V. D. gear, owing to its long buoyant headline, will enable it to catch hake floating at a greater distance from the sea bed than can be reached by the headline of the S. O. T. The denser the shoal of hake, the greater the number of hake taken by the V. D. but missed by the S. O. T. Such an explanation fits the facts as they apply to the hake fishery. Yet it seems that in the trawled herring fishery, a fishery for a species which is more pelagic in its habits than the hake, the S. O. T. had a greater efficiency than the V. D.

Let us endeavour to assess the effect of introducing the V. D. gear into the hake fishery, by considering two identical stocks of hake, one of which is fished by the V. D. and the other by the S. O. T. At the end of a year, say, the stock fished by the V.D. will have yielded a greater weight of fish, but will be left with the prospect of a lower catch in unit time, than that fished by the S. O. T. Now let an abundant year-class enter the fishery, in both cases. In the case of the stock fished by the V. D. gear, the new year-class, during the period when it is still relatively concentrated, will be very much more heavily cropped than that in the stock fished by the S. O. T. At the end of this year, therefore, the V. D. will have taken enormous quantities of small hake, giving a much greater total yield of hake, than the S. O. T., especially if the V. D. cod-end is of smaller mesh. But, as the new year-class becomes thinned out in subsequent years by fishing operations, natural mortality, and by the natural scattering and spreading out into deeper water as the fish grow larger, the toll levied by the two types of gear becomes much more even. Meanwhile, however, the initial very heavy cropping of the year-class by the V. D. gear will have resulted in a reduction of its strength to an extent which will more than offset any residual superiority of fishing power still possessed by the V.D. trawl over the S. O. T. At the end of a certain small number of years, therefore, we should expect to find the stock fished by the V. D. yielding definitely less larger hake, though more smaller hake (derived from subsequent spawnings) in unit time, than that fished by the S. O. T. This

effect is not the same as that of, say, doubling the fishing power of the S. O. T. as, for instance, by doubling the number of ships using it. In the latter case there would be a doubling of the landings of all sizes of hake and an evenly distributed strain; with the V. D. the strain appears to be exceedingly heavy when the hake are dense, as they are when a successful brood enters the fishery, and it is then, in my view, that the differential destruction of the year-class takes place.

The effect of introducing the V. D. trawl into the hake fishery, from the argument given above, would be to give enormous catches of small hake whenever a rich year-class enters the fishery, but a corresponding depression, later, in the catches of older and larger hake. This corresponds with the actual results of the hake fishery in recent years. The character of the fishery has changed to one based largely on small hake.

At an Inter-Departmental Conference on Fishery Investigations, an enquiry was held into the effect of the V. D. gear, with special reference to the haddock fishery. It was concluded that the V. D. gear was the more efficient apparatus for haddock, and that the use of this gear reduces the chances of a haddock being able to escape to live to a good marketable size; the gear was described as "a method of fishing capable of eliminating enormous numbers of fish before they have reached maturity, or even marketable size."

From the biological point of view, there need not be great alarm at the change in the character of the fishery, to one based largely on small hake, since there will always, probably, be enough survivors to reach maturity and maintain the species; but, from the economic point of view, a fishery based on small fish is at the mercy of natural fluctuations in the strength of the year-classes, to a much greater extent than a fishery in which there is a larger proportion of bigger and older fish, to act as a reserve in the intervals between the appearances of successful year-classes. Moreover, in the new conditions, a rich year-class will be so heavily fished as to glut the market with small hake. This actually happened in 1925 and 1926, when a prominent English trawler owner complained (4) of "the terrible gluts, which are one of the principal causes of the shocking conditions in which the fishing industry finds itself to-day." Since then, however, the market for small hake has improved, though still very sensitive when landings of small hake are heavy, and the abundance of small hake, in 1930, was welcomed.

When the V. D. gear was still a novelty, in September, 1923, the writer saw it in use for the first time, and in a short account of it (5) he records the fisherman's opinion that the new gear is more merciful to the small hake than the old. But there is good reason to believe that, in 1923 and

1924, small hake were comparatively scarce, owing to a failure of year-classes. With the entry of the rich year-classes, probably of 1920 and 1921, into the fishery, vast catches of small hake became a prominent feature of the fishery, and, in October, 1926, the writer saw a haul, by no means exceptional, which included 5 score of big and medium sized hake, but no less than 80 baskets of small hake.

Summary.

The efficiency of the Vigneron-Dahl trawling gear is compared with that of the steam otter trawl, with especial reference to the hake fishery. On the data available, it appears that the V. D. is generally more efficient than the S. O. T., but in very varying degree. Its superiority varies to a considerable extent with the varying concentration of the hake, and is greatest where the concentration of hake is densest.

It is concluded that the effect of introducing such a gear into the fishery will result in enormous catches of small hake whenever a rich year-class enters that fishery, but in a corresponding depression later in the catches of larger hake. Its tendency, in short, will be to change the fishery into a violently fluctuating one based chiefly on small fish. This appears to have actually happened in the hake fishery.

Literature.

(1) Le Gall, J. La Pêche Maritime etc. 14e Année No. 666. 1931.
(2) Hickling, C. F. Fisheries Investigations, Series II. Vol. X. No. 2. 1927.
(3) Garstang, W. Buckland Foundation Lecture. "Fishing News", June 7, 1930.
(4) Lawford, E. D. W. "The Times", Sept. 5, 1926.
(5) Hickling, C. F. "Fish Trades Gazette", Nov. 17, 1923.
(6) Edser, T. Rapports et Procès-Verbaux. Vol. XXXVI.

Postscript. Through the kindness of trawler owners at Fleetwood, I have had access to the results of some trawlers at the time of conversion from the S.O.T. to the V.D. gear. These tend to confirm my conclusion that the superiority of the V.D. gear varies "with the varying concentration of the hake, and is greatest where the concentration of hake is densest". Thus, in the months from May to July, when the spawning concentrations of the hake occur (2), the V.D. caught three times the quantity of big and medium hake (which include almost all the spawners) caught by the S.O.T., but slightly less small hake than the S.O.T., per day's absence: whereas in autum, when the small hake are taken in quantities in the shallower waters (2) the V.D. caught little more big and medium, but three times the quantity of small hake, caught per day's absence by the S.O.T.

On the first voyages with the new gear an additional expert fishing skipper was carried as instructor; I understand that the subsequent voyages generally shewed less striking results.

Fish Marking in the Barents Sea.

By

M. Idelson.

State Oceanographical Institute, Moscow.

In December 1929 the State Oceanographical Institute of the U. S. S. R. began a scientific-industrial investigation of the principal kinds of food fishes in the Barents Sea (cod, haddock, Norway haddock, catfish, plaice,

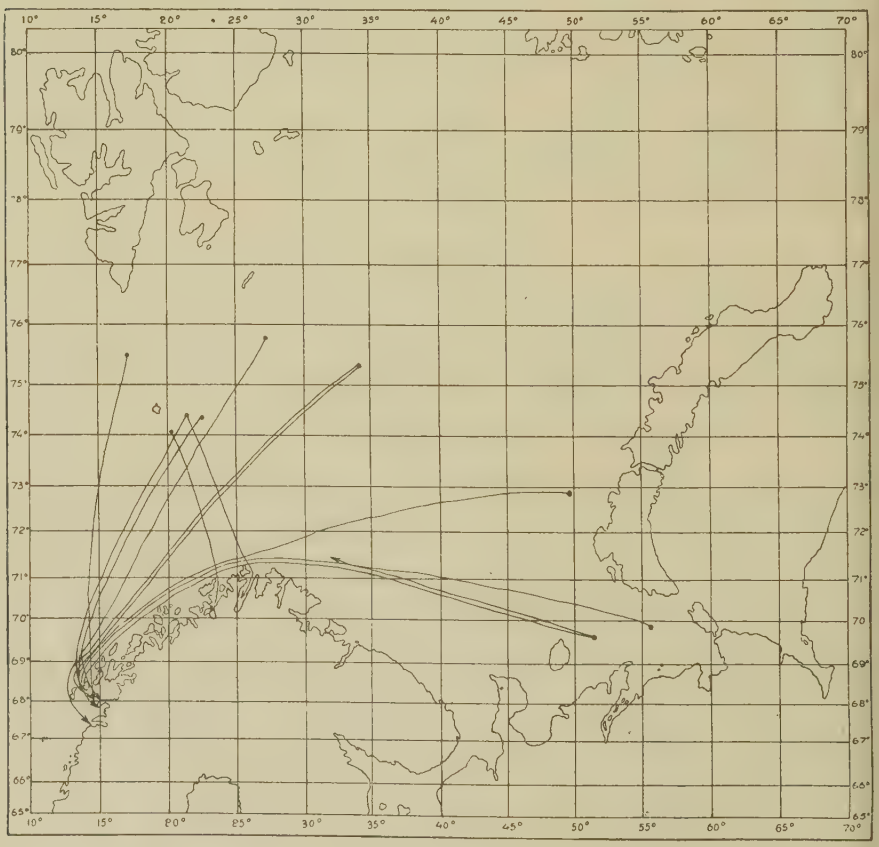

Fig. 1. Migrations of the cod marked by the Oceanographical Institute of the U. S. S. R. in the year 1930.

etc.). The programme of these investigations includes the marking of fish, which the Institute has been doing since 1928.

Up to the present, out of the 4847 fish marked, only 30 have been caught and returned: 24 cod, 4 haddock, 1 *Anarrhichas minor* and 1 *Hippoglossoides platessoides.*

Some of the marked fish were caught not far from the place of liberation soon after marking, whilst some of the marked cod have been at liberty for several months, having travelled over long distances. The most interesting itineraries of the cod marked by the Oceanographic Institute in VI-X 1930 and re-captured in II-V 1931 are shewn on the accompanying chart. The itineraries traversed by the cod from the eastern part of the Barents Sea form an interesting addition to our knowledge of the migration routes of the Barents Sea cod (see J. Hjort. Fig. I. "Fluctuation in the year classes of important food fishes". Journal du Conseil, Vol. I, No. 1, 1926).

The marking of fish will be continued in 1931, and the intention is to mark 10,000 fish. The data dealing with the migratory paths followed by the marked fish will be published at the end of 1932 in the Transactions of the State Oceanographical Institute.

Details of marks, rewards payable etc. have been embodied in the pamphlet, to be published in this Journal, describing fish marks in use in various countries.

The Spawning Mark on Sea Trout Scales.

By

J. C. Mottram. M. B. Ldn.

The spawning mark on salmon scales has proved a valuable sign and has added considerable knowledge to the life history of the salmon. The mark appears to be entirely reliable, so that whenever a salmon spawns a record is left on its scales, and when the mark is absent one may conclude that the fish has never spawned.

This, however, does not apply to the scales of the brown trout. Every scale reader will agree that a brown trout can spawn and not leave a record of that event on its scales.

The question arises, what is the position as regards the sea trout? Does this fish take after the salmon or the brown trout?

Mr. Nall in his book on the sea trout infers that the absence of a spawning mark is evidence that the fish has not spawned; he treats the sea trout as salmon are treated by scale readers.

This is a question of considerable importance because much of the life history of sea trout is deduced from scale readings, and especially their spawning habits from the spawning mark.

I have examined the sex organs of several hundred sea trout older than herling, caught in the summer and autumn in the rivers and lakes of England, Scotland, Ireland and Norway, and I have not found a fish which is not going to spawn the following winter.

In contrast to this, Mr. Nall from the scale readings finds a considerable proportion of fish older than herling, which are maiden fish: that is, fish which passed through the second winter after becoming herling and did not spawn.

I propose therefore to consider the S. M. in sea trout scales in detail. The S.M. is due to erosion of the margin of the scale which occurs during

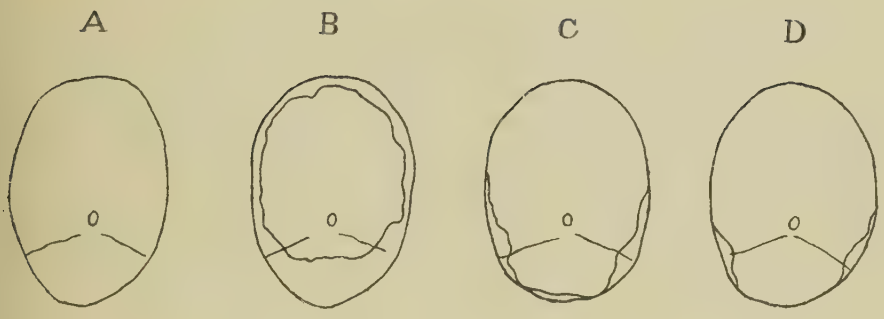

Fig. 1.

maturation of the eggs and sperm. Fig. 1 shows at A a scale before erosion; B a scale which has suffered much erosion, extending all round the margin and involving a great part of the external portion of the scale; C a scale where the erosion is confined more or less to the shoulder of the scale; D a scale where very little erosion has occurred, in this case it is confined entirely to the shoulder of the scale.

Fig. 2 (a) gives a magnified view of a scale and shows the junction of the internal and external part of the scale, the shoulder, where the scale ridges or lines fade out into the external part of the scale. Let us suppose that this scale suffers a very small amount of erosion at the shoulder included within the dotted lines in the figure, then after erosion the scale will have the appearance seen in (b) where a few of the outermost ridges are seen to be cut off. When the scale is repaired after spawning, the new ridges laid down will make up this gap by curling round the cut ends of the eroded edges, as shown in Fig. 2 (c).

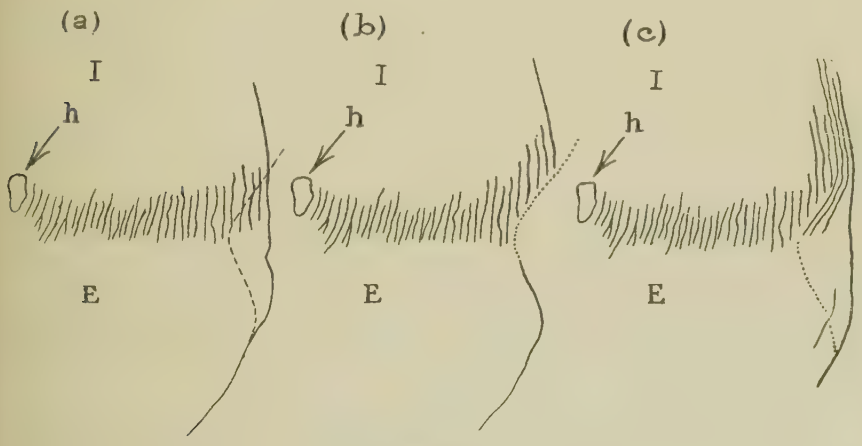

Fig. 2.

This curling round of ridges at the shoulder will then be the only evidence on the scale that the fish has spawned.

It is important to recognise that a small amount of erosion will leave this slight S. M. at the shoulder of the scale: if this mark is present, then erosion must have taken place and since erosion is associated with spawning, it certainly proves that the fish has spawned.

Now Mr. NALL does not consider that this is a spawning mark in proof

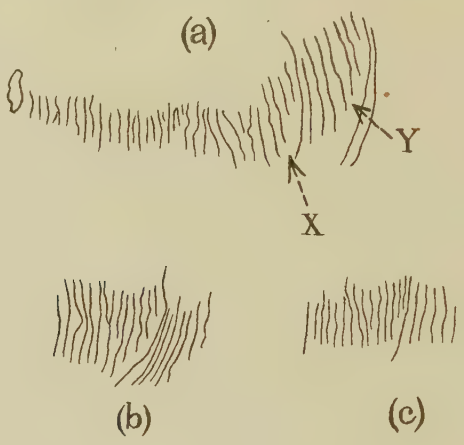

Fig. 3.

of which, one has only to refer to the figures in his book. He figures 31 scales of sea trout and in at least three of these (approximately 10 %) he altogether neglects this evidence of slight erosion at the shoulder and therefore evidence of spawning; unless one assumes that slight erosion occurs without spawning, which is a difficult opinion to maintain, since who can say where erosion associated with spawning begins or ends?

In Fig. 3 tracings are shown from Mr. NALL's book of the three scales referred to above: (a) is from the scale facing page 50, the curling round of the edges at Y, Mr. NALL calls a spawning mark but a similar occurrence at X, he does not consider to be a spawning mark.

(b) is from a scale facing page 30, this he classifies as a maiden fish though it shows well-marked erosion at the shoulder; similarly (c) is from a scale facing page 81 and here he classifies it as a? spawning mark. Evidently in this case Mr. NALL is in doubt as regards the evidence of slight erosion at the shoulder. It is obvious therefore that Mr. NALL has overlooked evidence of slight erosion.

There is another mark at the shoulder which may lead to confusion and a false impression of slight erosion: a curling-in, or sometimes out,

of the first two or three summer ridges may occur following the winter check but with an absence of any erosion of the winter ridges.

Returning to the question of slight erosion at the shoulder of the scale, it is possible that this may occur in winter without spawning, especially if the fish should elect to winter in the river without spawning as many herling sea trout do. Proof of this would be hard to obtain and even if obtained, would make the interpretation of the S. M. in sea trout still more open to doubt.

There is one other difficulty with regard to the S. M.: a spawning mark may be included in a subsequent erosion if this is very extensive and especially is a small S. M. confined to the shoulder of the scale, likely to be thus included.

One must conclude therefore that the S. M. in sea trout is not so reliable as is the case in salmon and its absence does not definetely show that the fish is a maiden one. It follows that many of Mr. NALL's deductions with regard to the life history of the sea trout, gained from an examination of scales, is open to doubt.

The Age and Growth of Salmon caught in the Polish Baltic.

By

Boris Dixon.

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Salmon *(Salmo salar)* caught by the Polish fishermen in the Bay of Danzig and in the Baltic beyond the territorial line from 18°12′ E. to 18°36′ E. may be subdivided into three groups, varying not only as to the time, place and manner of capture, but also with regard to certain biological features:

1. Small *S. salar*, the so-called "mielnica", caught with set and drift nets and seines in the littoral waters of Danzig Bay and in the Baltic along the shores of Hel peninsula from January to May.

2. Large *S. salar*, caught with drift nets in the Bay of Danzig and in the Baltic during April and May.

3. Large *S. salar*, caught with lines in the Baltic from October to February.

In order to determine the composition of the stock of the three above-mentioned groups of *S. salar*, we have collected material consisting of scales and length measurements of the following specimens: 1) 70 small *S. salar*, "mielnica" from the littoral catch with drift nets in the Bay of Danzig in March and April 1925, 2) 100 *S. salar*, caught on 15th May 1928 with drift nets and 3) 30 *S. salar* caught in January and February 1925 with lines. All these specimens belong without doubt to the Atlantic species, *S. salar* L.

The scales were examined with regard to age as well as to the width of the zones ("the calculated edge" according to H. J. Buchanan-Wollaston) for further elaboration of the growth by means of Prof. Edinger's projection apparatus, with oculars 4 and 6 and objectives 1 and 2 (Leitz model 1926).

The use of this apparatus greatly facilitated the examination of the

scales, especially in determining the boundaries between the yearly periods of river life, which are often so obscure with *S. salar*, particularly for the fish with 3 and 4 years life in the river. Strips of cardboard 4 × 20 cm. in size were used to note "the calculated edge".

Further, in applying Ejnar Lea and Knut Dahl's method for calculating growth we used Lea's board.

We give below, for each kind of *S. salar*, the grouping of the material with regard to age and length of river and sea life, and the data for the rate of growth of each particular kind, together with a comparison of the whole material and the conclusions reached.

We must mention that, owing to the lack of Polish terminology for the definition of the particular periods of the salmon's life, we use the accepted English terminology for the biology of *S. salar*. Thus the term "Smolt" is used to denote the Salmon when it enters the sea from the river. In this way the 2, 3 or 4 years smolt corresponds to a *S. salar* which has spent 2, 3 or 4 years in the river before its first migration to the sea.

I. Stock of small *S. salar*, the so-called "mielnica".

Fishing grounds. From year to year towards the end of winter and early spring numbers of "mielnica" visit the Polish sea shores for feeding; these are the small *S. salar* from 37 to 45 cm. in length.

The manner of fishing by means of seines, set and drift nets shows that the "mielnica" during their stay in the Bay of Danzig invariably keep close to the shore; they are caught along the shores from Hel peninsula down to the shores of Danzig. Gull Bank is the northern boundary line to which the "mielnica" migrate in the Bay of Danzig; beyond this line they never go.

Fishing period. The season at which the "mielnica" appear on the Polish shores is indicated in the following table, based upon the statistical data of the Sea Fishery Board for the period 1924—1928.

The catch of "mielnica" in the period 1924—1928.

Months	100 kg.	%
January	139	13.2
February	199	18,4
March	224	21.2
April	359	34
May	120	11.4
June	25	0.24
November (1928)	4	0.38
December	6	0.57

Thus the period between March and April is the time of the greatest concentration of the "mielnica" along the Baltic shores, while in May the catches begin to diminish.

Feeding. The time when the "mielnica" remain along the Polish shores is, according to our observation, the period of the most intensive feeding. The food consists chiefly of young lesser sand eels (*Ammodites tobianus*), sticklebacks (*Gasterosteus aculeatus*) and sometimes single specimens of cod (*Gadus morrhua*).

As for the sex composition of the stock, it has been noticed that the males predominate, forming 78 % of the material examined.

The comparison of the results of the analyses regarding size, age, number of sea and river periods, as well as the rate of growth, gives us the following description of the "mielnica".

Size of fish. Grouping 70 of the "mielnica" examined according to length of body, we obtain the following description of their dimensions:

Length in cm.	Number of fish	Length in cm.	Number of fish
38—40.....	6	43—44.....	7
40—41.....	3	44—45.....	13
41—42.....	10	45—46.....	15
42—43.....	10	47—48.....	4
		48—49.....	2

As much as 80 % of the whole catch falls within 41—46 cm. in length.

Age. With regard to age the stock of the "mielnica" has quite a definite character — 80 % of the whole stock are 4 years old; the rest, i. e. 20 %, are 5 years old.

All the "mielnica" examined, without exception, had spent only one year in the sea. The period of their river life is therefore 3 and 4 years respectively; thus we may say that the stock of "mielnica" chiefly consists of:

3 years smolts, which form 80 % of the stock, and
4 - - - - 20 % - - -

Rate of growth. Below we give a comparison of the length of the "mielnica" in cm. reached in each year of life calculated by the method of back calculation. This also gives further indications of the yearly growth increments — the growth rate.

Calculated length in cm.

Smolt age	River life				Sea
Years....	1	2	3	4	1
3-years smolts.....	3.9	8.2	13.3		43.4
4-years smolts.....	2.9	6.3	10.1	13.1	43.2

Growth increments in cm.

Smolt age	River life				Sea
Years....	1	2	3	4	1
3-years smolts.....	3.9	4.3	5.1		30.1
4-years smolts.....	2.9	3.4	3.8	3.4	29.7

Conclusions. Summarising the results we learn that the stock of "mielnica" consists exclusively of 4 and 5 years old fish. The characteristic features of this small *S. salar* is their long river life of 3 and 4 years duration and 1 year's life in the sea. The complete absence from the "mielnica" of specimens with a 2 years river life proves that these *S. salar* originate from the northern rivers.

II. Stock of Salmon caught with drift nets.

Age. The stock of salmon caught with drift nets in the Polish Baltic and the Bay of Danzig consists of fish from 4 to 6 years old, with a preponderance of 6 years old specimens. The analysis of our sample of a 100 fish gives us the following picture of the age composition in percentages:

4 years old fish — 7 %
5 - - - — 25 %
6 - - - — 65 %
7 - - - — 3 %

Size of fish. Owing to the preponderance of old fish in the stock the average length of the fish amounts to 90.2 cm. Subdividing them into 10 cm. groups according to length we obtain the following percentage proportions:

up to 70 cm. — 5 %
70 — 80 - — 19 %
80 — 90 - — 19 %
90 —100 - — 30 %
above 100 - — 27 %

In this way the greater part (three fifths) of the stock consists of fish from 90 to 112 cm. However, with regard to age the preponderance of the 6 years old fish, which form two thirds of the whole quantity, is characteristic.

In analysing the material it is striking that the 6 years old fish predominate. These old fish are nearly always represented in very small numbers in the material of the investigators occupied with spawning salmon. It is curious to compare our material in this respect with the figures of the Scottish investigators W. MENZIES and P. R. C. MACFARLANE, who have published the results of their examination of the catch of salmon in the river Spey in the years 1923, 1924, 1925. Below are given the particulars of the 6 years old fish quoted from these authors:

Year	Author	Number of examined fish	6 years old fish	%
1923	MENZIES	1.712	45	2.6
1924	MENZIES	2.398	54	2.3
1925	MENZIES and MACFARLANE.	1.443	51	3.5

It is to be regretted that the above-mentioned authors have not given the length of sea life of the fish with spawning marks, which figure in the tables. Therefore we shall agree to call 6 years old fish those with the "spawning mark", which have spent 3 winters in the river.

Even if we accept for 6 years old fish all those that have the "spawning mark", the percentage of fish of that age would be very small, namely — for 1923 — 5.4 %, 1924 — 5.3 % and for 1925 — 10.1 %.

Until now, as far as we know, there has been no analysis made as to the composition of the salmon stock caught in the sea, all the data referring to the biology of salmon being based exclusively on river material.

I venture to express the opinion that a considerable part of the fish caught in the sea are surely individuals which have lost the faculty of propagation and remain in the sea for feeding. I find the confirmation of my supposition in the considerable percentage of fish with the "spawning marks". To every 100 *S. salar* caught with drift nets 12 have a „spawning mark", and to every 30 *S. salar* caught with lines as many as 6, i. e. 20 %. Actually the percentage is probably greater, for, as is well known, the scales of all fish which have spawned do not possess a "spawning mark". How great this percentage is for our salmon one may see from the fact that for particular Scottish rivers the percentage varies between 4 and 7.8 %.

Smolt age and sea life. With regard to the classification of the

salmon stock caught with drift nets as to the number of years spent in the river and sea, the following table gives the percentage number of fish of each category.

	River life			Sea life		
Years....	2	3	4	2	3	4
Number of fish	14	69	17	33	65	2

The greatest percentage, as we see, falls to the 3 years smolts, and the fish which have spent 3 and 4 years in the river form altogether 86 % of the whole stock. Such a long period of river life is peculiar to *S. salar* originating from cold northern rivers. In connection with this it seems very doubtful if the upper tributary of the Vistula shares in supporting this stock of salmon. The material examined by me referring to the sea-trout of the upper tributary of the Vistula — the Dunajec — indicates that the stock of these sea-trout consists of 79 % of fish which had remained in the river for 2 years, and only 21 % were 3 years smolts; 4 years smolts are not found at all.

Growth: calculated lengths in cms. Calculation of the lengths of the fish by E. Lea's method gives the following picture of the growth-rate during river and sea life (in cms.):

Smolt age	River life				Sea life			
Years....	1	2	3	4	1	2	3	4
2 years smolt ..	4.9	11.7	—	—	40.3	73.3	91.2	10.6
3 - - ..	4.8	9.1	15.7	—	43.1	75	..	..
4 - - ..	4.3	8.0	12.1	16.8	47.8	83.0	102.5	..

In comparing these figures with those of the Scottish authors calculated by the same method for salmon of the Scottish rivers we do not find a great difference in the growth-rate between the Baltic and Scottish salmon during their river life. The growth of the 2 and 3 years smolts in certain Scottish rivers is represented by Menzies as follows:

Rivers	River life		
Years....	1	2	3
Dee	4.4 cm.	10.0 cm.	12.7 cm.
Spey	4.5 -	10.5 -	12.9 -
Findhorn	4.5 -	10.5 -	13.2 -
Forth	4.7 -	11.1 -	14.1 -
Don	5.3 -	11.5 -	
Tweed	5.8 -	13.1 -	

As to the growth during sea life our salmon show a still smaller difference in comparison with those of the Scottish fish. Thus Scottish salmon reached the following lengths:

1. First year in the sea.

1923..... 39.8—44.5 cm.
1924..... 43.3—43.5 -
1925..... 43.2—43.5 -

2. Second year in the sea.

1923..... 73.4—74.4 cm.
1924..... 73.3—74.3 -
1925..... 74.1—76.9 -

3. Third year in the sea.

1924..... 93.8—97.6 cm.

Growth increments in cms. In order to explain the growth increments of *S. salar* in the period of their river and sea life, I give below a table dividing the salmon into three groups in regard to the length of their river life.

Smolt age	River life				Sea life		
Years	1	2	3	4	1	2	3
2 years smolts ..	4.9	6.8	—	—	33.5	32.7	18.2
3 - - ..	4.8	4.3	3.9	—	30.1	31.9	19.9
4 - - ..	4.3	3.7	4.1	4.7	31.0	35.2	19.5

The data adduced as to growth confirm the well known fact that the longer the river life is, the slower is the rate of increase in length during this period.

As for the length and growth in the sea, the greatest dimensions are reached by fish with 4 years of river life (102.5 cm.).

This may undoubtedly be explained by the fact that under more or less equal conditions of feeding in the sea the total growth, during the 4 years in the river, is always larger than that of the 2 and 3 years smolts. Therefore the 4 years smolts, which towards the end of the 4th winter have a length of 16.8 cms., reach, as we know, towards the end of the 3rd winter in the sea a length of 102.5 cm.

III. Line-caught Salmon.

The description of this group of *S. salar* is given on the strength of an analysis of only 30 fish. I am inclined to think that this stock of salmon is identical in origin with the stock caught with drift nets. The comparison of these groups, however, gives a certain divergence which I explain by the insufficient number of line-caught salmon in the sample.

Age. The material examined gives the following grouping of fish with regard to age, in percentages:

4	years	old	fish	—	7 %
5	-	-	-	—	27 %
6	-	-	-	—	53 %
7	-	-	-	—	10 %
8	-	-	-	—	3 %

The 6 years and older groups predominate here too and reach, as with those caught with drift nets, 66 % of the whole quantity. The proportion of 4 years old fish also remains almost the same as that of the drift net group and amounts to 7 %. Thus with regard to age we find no difference in comparing them with the salmon previously analysed. The increase of the number of 4 and 8 year fish to 13 % suggests that in the composition of the stock a considerable part is composed of individuals which have lost the faculty of propagation, as such fish are never found spawning.

Size of fish. Grouping the fish according to body length we have the following picture of the predominance of the larger specimens:

up	to	70	cm.	—	2
70	—	80	-	—	3
80	—	90	-	—	3
90	—	100	-	—	9
100	—	110	-	—	7
above		110	-	—	6

Smolt age and sea life. The results obtained from the scales of this group regarding the length of the period of river life give us a somewhat different grouping from that of the previous division, namely:

2 years smolts — 40 %
3 - - — 47 %
4 - - — 13 %

The predominance of the 3 and 4 years smolts remains, whereas the group of 2 years smolts amounts to 40 % against the 14 % in the drift net material. This divergence may be explained by accidental distribution in the sample. It is to be noted that the above-mentioned material was not collected in the course of one day, as was the case with the drift net material, but in the course of a month.

Growth rate. In order to show the growth rate of line-caught salmon we give the following table:

Calculated lengths in cms.

2 years smolts						3 years smolts					
River life		Sea life				River life			Sea life		
1	2	1	2	3	4	1	2	3	1	2	3
5.4	11.5	37.6	71.3	91.8	106.1	4.4	7.8	13.9	43.1	76.8	98.9

The diminution of the growth of the 3 years smolts demonstrated for the drift net material is to be found here also.

IV. Comparison of the material and conclusions.

In order to explain the difference between the three samples of *S. salar* analysed with regard to age, period of river and sea life, and growth-rate, the foregoing analyses of each different group of salmon are compared.

Analysis of age.

The proportion of the different ages in the stock, in percentages.

Years....	4	5	6	7	8
Stock "Mielnica".....	80	20	..	..	..
— Salmon (drifts nets)	7	25	65	3	..
— Salmon (lines)	7	27	53	10	3

The above comparison indicates an absolutely different composition of the stock of "mielnica" in comparison with the material from drift nets and lines; with regard to age the two latter show no significant difference.

River and sea life.

The proportion of fish with various lengths of river and sea life, in percentages.

	River life			Sea life			
Years....	2	3	4	1	2	3	4
Stock "Mielnica".....	..	80	20	100	..	..	..
— Salmon (drift nets)	14	69	17	..	33	65	2
— Salmon (lines) ...	40	47	13	..	17	63	20

In the stock of "mielnica" there is a total lack of fish with 2 years of river life, and this supports the view that the stock of "mielnica" originates from rivers further north than those from which the drift net and line caught salmon were derived.

Growth rate.

Calculated length in cms.

Smolt age....	3 years smolts				4 years smolts				
	River life			Sea	River life				Sea
Years....	1	2	3	1	1	2	3	4	1
Stock "Mielnica".....	3.9	8.2	13.3	43.4	2.9	6.3	10.1	13.5	43.2
— Salmon (drift nets)	4.8	9.1	15.7	43.1	4.3	8.0	12.1	16.8	47.8
— Salmon (lines) ...	4.4	7.8	13.9	43.7	..	..	..	..	..

Comparing the length of the "mielnica" with those of the drift net and line caught salmon of the same age we find that the growth of the "mielnica" in their river life is much slower. The considerable difference in growth, to the disadvantage of the "mielnica", indicates that the stock of these salmon originates from rivers with worse conditions for feeding.

In spite of the slow growth during river life, the "mielnica" nevertheless reach, towards the end of the 1st year in the sea, the same length as the salmon caught with drift nets and lines.

The average length of the "mielnica" towards the end of the first year of sea life, for the group of 3 years smolts, amounts to 43.4 cms., i. e. almost the same as for the large salmon. But the 4 years smolts of the "mielnica" are considerably shorter than the drift net salmon; the average length of the "mielnica" amounts to 43.2 cm. against 47.8 cm. in the case of drift net caught salmon.

The same thing is still more clearly emphasised by the analysis of the growth of the groups of salmon given in the following table:

Yearly growth in cm.

Smolt age....	3 years smolts				4 years smolts				
	River life			Sea	River life				Sea
Years....	1	2	3	1	1	2	3	4	1
Stock "Mielnica"	3.9	4.3	5.1	30.1	2.9	3.4	3.8	3.4	29.7
— Salmon (drift nets)	4.8	4.3	3.9	30.1	4.3	3.7	4.1	4.7	31
— Salmon (lines)...	4.4	3.4	6.1	28.8	..	..	..	..	..

The data as to the growth of the 4 years smolts caught with lines are not shown owing to the insufficient number of specimens in the sample.

The slow growth rate of the "mielnica" in their first year of river life in the group of three years smolts, is not reflected in the lengths of this group at the end of their first year in the sea, owing to a considerable growth during the 3rd year in the river. Whereas the group of 4 years "mielnica" smolts shows — as has already been mentioned — a diminution of the growth rate in comparison with the drift net caught salmon during the whole period of both their river and sea life.

The above results of the analysis of the stock of salmon which constitute the basis of the catches in the Polish littoral fishery, permit, in my opinion, the following conclusions to be drawn.

1. The characteristic features of the "mielnica" are their one year's stay in the sea, and their 3 and 4 years stay in the river, while the 2 years smolts are altogether absent.

2. The characteristic feature of the groups of large salmon is the presence, in a preponderant number, of old fish, which are probably not capable of spawning.

3. All the three groups of salmon caught in the Baltic come from northern rivers with no, or only an insignificant, percentage of 2 years smolts.

4. The two groups of large salmon caught with drift nets and lines have probably a common origin, showing a resemblance both in the composition of the stock and in the growth rate.

5. The group of small salmon — "mielnica" — come from a river which is probably colder, and more northern, than the salmon of the first two samples.

Age and Growth Rate of the Sea-Trout (*Salmo Trutta*) of the Rivers Reda and Dunajec.

By

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In order to differentiate the trout of the rivers Dunajec and Reda with regard to age, duration of life in the river or the sea, and growth rate, we have analysed the body lengths and scale measurements of 1) 52 sea-trout from the Dunajec, collected in 1924 by Dr. Fr. Lubecki and sent to me for examination, 2) 40 sea-trout of the Reda "black" race, collected in autumn 1928, and 3) 34 specimens of the Reda "silver" race, also collected in 1928.

As was done in the investigation of the salmon caught in the Bay of Gdynia, we used the Edinger apparatus for the examination of the scales and the E. Lea board for back-calculation of the growth rate.

I. The Dunajec Sea-Trout.

Spawning-grounds. In some of the upper tributaries of the Vistula (Skawa, Sola) there are still some spawning grounds of *Salmo salar*. In the river Dunajec, however, we find on the spawning grounds the large sea-trout exclusively. In the upper part of the Dunajec, below Nowy Targ, spawn for artificial propagation has been taken every year since 1924. The number of fish used for this purpose during the last 7 years was from 80 to 400, whereas the maximum production in 1928 amounted to 1,200,000 eggs.

Industrial Fisheries. Our investigations made hitherto prove that the Dunajec sea-trout plays no part in the sea fishery in the Bay of Danzig. Numerous examinations of the salmon sea fishery, made by Dr. Fr. Lubecki and myself, have not as yet revealed any Dunajec sea-trout in

these catches. It can be assumed that the absence of the trout in this sea fishery is due to the fish entering the Vistula from the sea in autumn, that is, at a time when the fishermen do not prosecute the industrial salmon fishery.

The sea-trout of the Dunajec is, however, of economical importance to the fishermen of the Vistula district, especially the Free City of Danzig, to which fishery for salmon and sea-trout entering the Vistula mainly belongs. Apart from the fishery in the upper tributaries of this river the trout fisheries, on the other hand, are of less importance to the Polish fishermen on the Vistula.

Age. Examination of 52 specimens of the Dunajec sea-trout gives us the following age distribution:

4 years old	— 17 %
5 — - -	— 79 %
6 — -	— 4 %

Length. In comparison with the sea-trout of the Scottish, Norwegian and Swedish rivers, the Dunajec race is distinguished by its large size, sometimes reaching 105 cm., which is no smaller than the salmon.

In our sample the fish are classified as follows:

up to 70 cm	— 9
70—80 -	— 22
80—90 -	— 15
90—100 -	— 5
over 100 -	— 1

Such a preponderance of the large sea-trout is not found in the fisheries of other rivers. In Scottish rivers, for instance, the sea-trout from 70 to 80 cm. amount, according to Mr. Nall, in the Ailort river to 0.4 %, in the Tweed to 1.7 % and in the Ewe to 0.2 %. In the material collected, consisting of 1387 fish, arranged by Knut Dahl, we find no sea-trout over 65 cm.

River life. 79% of the fish examined had lived in the river 2 years
21% - - - — - - - - - 3 years

Sea life. In regard to sea life we established the following proportions:

2 years in the sea	33 %
3 — - - -	65 %
4 — - - -	2 %

Preponderance of 2 years old smolts, and scarcity of 4 years old, are distinctive features of the salmon and the sea-trout inhabiting warmer rivers. They generally spawn at 5 years of age (79 %), and only 17 % come to the spawning grounds at 4 years of age.

Growth rate. By using the Lea board we obtained the following lengths of the sea-trout at particular ages, and also the yearly increment.

	River Life			Sea Life			
	1	2	3	1	2	3	4
2 years old smolts . .	8.6	17.4	. .	47.6	63.0	80.7	83.8
3 — — — . .	6.8	12,0	19,7	48,6	70,7	76.7	. .

For the sea-trout of the Scottish rivers, Mr. G. H. Nall has established the fact that the sea-trout grows more rapidly during the period of river life. In comparison with the salmon, the Dunajec sea-trout confirms this observation.

The lengths of smolts from 13 Scottish rivers vary, according to Mr. Nall, between the following figures:

2 years old smolts — 14,6 — 20.1 cm.
3 — - — — 18.5 — 22.8 -

The growth-rate during the river period does not determine the length of the fish at an older stage. This is decided by the duration of the sea life and the ability to utilize fully the feeding conditions; thus, if we disregard the greater length of the 2 and 3 years old smolts in some of the Scottish rivers, the length of the fish after three years of sea life varies generally between 44 and 53 cm., i. e. it attains the length of the Dunajec sea-trout after one year of sea life. The sea-trout of the river Tweed are an exception. Comparison with the Scottish material emphasizes the exceptionally rapid growth of the Dunajec sea-trout, which could be considered to be the largest. An analysis of the lengths of 143 Dunajec sea-trout, made by me in 1924 on the Dunajec, revealed the fact that the proportion of fish from 70 to 90 cm. in length was 84 %, and of those with a length of over 90 cm., 11 %. Fish smaller than 65 cm. were not found in this case.

Yearly growth increments. The yearly growth increment, in centimetres, according to the particular years of river and sea life is given as follows:

2 years old smolts					3 years old smolts				
River Life		Sea Life			River Life			Sea Life	
1	2	1	2	3	1	2	3	1	2
8.6	8.8	30.2	15.4	17.7	6.8	5.2	7.7	28.9	20.1

Thus the total increase after three years of sea life amounts, for 2 years old smolts, to 63 cm., and after two years of sea life, for 3 years old smolts, to 50 cm.

II. The Sea-Trout of the Reda.

An analysis of the morphometrical characters of the Reda sea-trout (*vide* Journal du Conseil VI, 1, 1931) established the existence of two different biological races living in the Reda, namely the "black" race and the "silver" race, which have their spawning-grounds there, but which only exceptionally feed there. It would be interesting to ascertain whether the difference between these races is also shown in the composition of the stock, duration of the river and sea periods or the growth rate.

Our sample consisted of 40 sea-trout of the "black" race and 34 of the "silver" race.

1. The "Black" Sea-Trout.

Age. 40 specimens of the "black" trout, collected during the summer, gave the following proportions as regards age:

3 years old males only — 5 %
4 — - - - — 43 %
5 — - - - — 47 %
6 — - - - — 5 %

Length. Classifying the specimens according to their overall body lengths, the following figures were obtained:

up to 34 cm — 2
40—45 - — 2
45—50 - — 5
50—55 - — 7
55—60 - — 6
60—65 - — 7
65—70 - — 7
70—71 - — 4

Small fish not met with in the stock of the Dunajec sea-trout, i. e. fish not over 65 cm., amount to 72 %, and only 28 % are fish over 65 cm; the length, in general, does not exceed 71 cm.

River life. As regards life in the river we find, similarly to the Dunajec sea-trout, only two groups:

2 years of river life — 70 %
3 - - - - — 30 %

Preponderance of the 2 years old smolts and entire absence of 4 years old point to a moderate temperature in their native river, in this case the Reda.

Sea life. Regarding the sea life of the fish examined:

5 % lived in the sea 1 year
63 % — — 2 years
30 % — — 3 -
2 % — — 4 -

Growth rate. The table below gives the average lengths of the fish at various ages, and the yearly increments, calculated from scale measurements made by the Lea method.

Back-calculation of the lengths in cm.

2 years old smolts						3 years old smolts					
River Life		Sea Life				River Life			Sea Life		
1	2	1	2	3	4	1	2	3	1	2	3
9	16.1	39.4	54.3	58.9	60.5	7.3	13.4	19.7	45.1	62.7	63
Growth increments in cm.											
9	7.1	23.3	14.9	4.6	..	7.3	6.1	6.3	25.4	17.6	..

From these figures we see that for the 3rd year in the sea the small sea-trout of the "black" race show a distinctly diminished growth (4.6 cm.), while the 2 years old smolts of the Dunajec sea-trout grow very vigourously, making in their third year of sea life increases up to 17.7 cm.

2. The "Silver" Sea-Trout.

Age. Of the fish examined

30 % were 3 years old
41 % - 4 - -
18 % - 5 - -
11 % - 6 - -

Length. Classification according to body length gives the following figures:

Length in cm.	No. of individuals
up to 40	2
40—45	4
45—50	10
50—55	2
60—65	2
65—70	5
70—75	5
75—80	2
over 80	2

In comparison with those for the "black" sea-trout, the above figures show that this stock is a differently characterised as regards age and length. 95 % of the "black" sea-trout consist of fish of 4—6 years of age; the proportion of adult fish of the "silver" trout, however, is reduced to 70 %, and the group of 3 years old fish amounts to 30 %, in comparison with 5 % for the "black" sea-trout. As regards body length we observed a larger proportion of fish over 65 cm (47 %), while in the stock of the "black" sea-trout it amounted to 28 % only. It should also be emphasized that more than $^1/_4$ of the sample of "silver" sea-trout are over 71 cm. while in the "black" race we find no fish of such lengths.

River life. Regarding the river life of the "silver" race the following proportions are given:

2 years old smolts — 82 %
3 - - - — 18 %

Sea life. For the whole sample of fish we established the following proportions regarding the years of sea life.

Years	%
1	41
2	30
3	24
4	5

Growth rate. Back-calculation of the lengths and the yearly increase gives the following results for the "silver" race:

Average lengths in cms.

2 years old smolts						3 years old smolts					
River Life		Sea Life				Sea Life			River Life		
1	2	1	2	3	4	1	2	3	1	2	3
8.6	18.8	41.1	55.4	70.2	76.0	8.0	17.3	23.4	46.7	63.5	72.0
Yearly increments in cms:											
8.6	10.2	22.3	14.3	14.8	..	8.0	9.3	6.1	23.3	16.8	9.5

Comparison of Results and Conclusion.

In order to complete the survey of the morphometrical differences between the three races of the sea-trout in question, the relevant figures as regards age and growth rate of these races may be compared.

Analysis of age. Classification of the material as regards age gives the following results:

Number of fish of different ages in percentages.

Races	Years				Total
	3	4	5	6	
Dunajec	..	17	79	4	100
"Silver"	30	41	18	11	100
"Black"	5	43	47	5	100

The material relating to the Dunajec sea-trout, as well as to the "black" sea-trout of the Reda, consisted of mature fish caught on the spawning grounds. In view of this, there are in the stock of these sea-trout mainly mature fish, i. e. 4—5 years old, which is 90 % of the whole stock. Among the Dunajec sea-trout we find no 3 years old fish, the 5 % of these 3 years old "black" sea-trout being explained by the presence of males, which mature earlier. The stock of the "silver" race, which does not spawn in the Reda, is not similar and contains up to 30 % of immature 3 years old fish. The gonads of the older fish are little developed even in October—January, i. e. during the salmon spawning season.

River life. As regards the time passed in the river, the following proportions of the particular races have been found.

Percentage number of fish with 2 and 3 years of river life:

Races	Years		Total
	2	3	
Dunajec	79	21	100
"Silver"	82	18	100
"Black"	70	30	100

Here we observe no significant difference. With respect to the "black" sea-trout it can be assumed that the temperature of the river Reda, which is the native river of this sea-trout, is somewhat lower than that of the river Dunajec and the river from which the "silver" sea-trout originates.

Sea life. Percentage number of fish in each year of sea life:

Races	Years				Total
	1	2	3	4	
Dunajec	..	33	65	2	100
"Silver"	41	30	24	5	100
"Black"	5	63	30	2	100

The above table shows the extent to which the stock of the "silver" race varies as regards age, some specimens migrating to the Reda independently of their age and the number of years spent in the sea.

Growth rate.

Back-calculation of the lengths of the fish in cm.

Race	2 years old smolts						3 years old smolts					
	River Life		Sea Life				River Life			Sea Life		
	1	2	1	2	3	4	1	2	3	1	2	3
Dunajec	8.6	17.4	47.6	63.0	80.7	83.8	6.8	12.0	19.1	48.6	70.1	76.1
"Silver"	8.6	18.4	41.1	55.4	70.2	76.0	8.0	17.3	23.4	46.7	63.5	72.0
"Black"	9.0	16.1	39.4	54.3	58.9	60.0	7.3	13.4	19.7	45.1	62.7	..

Yearly growth increments in cm.

Races	2 years old smolts					3 years old smolts					
	River Life		Sea Life			River Life			Sea Life		
	1	2	1	2	3	1	2	3	1	2	3
Dunajec.....	8.6	8.8	80.2	15.4	17.7	6.8	5.2	7.7	29.9	22.1	..
"Silver".....	8.6	10.2	22.3	14.3	14.8	8.0	9.3	6.1	23.3	16.8	9.5
"Black".....	9.0	7.1	23.3	14.9	4.6	7.3	6.1	6.3	25.4	17.6	..

From the above figures we gather that the length attained by the sea-trout of this, or any other, race is not dependent upon the growth rate of the fish during river life but upon the number of years passed in the sea. As regards size, the Dunajec race comes first, the second place being taken by the "silver" race, and the last by the small "black" sea-trout.

In order to eliminate a possible error in comparing the different ages of the fish, we compared the lengths of the fish of the same age, i. e. 3 years, 5 years and 6 years old individuals of both races. In this case the difference in growth rate is more emphasized, as is shown in the following table.

Races	3 years old			4 years old				5 years old				
	River Life		Sea	River Life		Sea Life		River Life		Sea Life		
	1	2	1	1	2	1	2	1	2	1	2	3
"Black"	8.4	18.4	34.2	8.9	15.9	42.1	48.8	8.4	15.4	38.1	50.6	63.3
"Silver"	9.8	20.6	43.3	8.5	19.4	42.4	58.5	8.3	16.8	38.4	53.0	70.5

Tabulating the results of our examination of the differences between the trout of the Reda and Dunajec leads to the conclusion that the three races of the Polish sea-trout established by us (the Dunajec, and "black" and "silver" sea-trout of the Reda), in addition to the actual morphometrical differences, vary also in respect of the length and age of the fish, as well as regarding the growth rate during their river and sea life.

Notes.

1.

Professor Ehrenbaum's Ausscheiden aus dem Staatsdienst.

Am 1. Dezember 1931 wird Professor Ernst Ehrenbaum, nach 21jähriger Tätigkeit an dieser Stelle, aus seinem Amt als Leiter der Fischereibiologischen Abteilung des Zoologischen Staatsinstituts in Hamburg ausscheiden, nachdem seine Regierung ihn fünf Jahre über die Altersgrenze hinaus in diesem Amt festgehalten hatte. Auch aus dieser nicht häufigen Verlängerung seiner Dienstzeit ergibt sich die grosse Bedeutung dieses in Deutschland und im Ausland gleich hochgeschätzten Meeresforschers.

Professor Ehrenbaum ist am 20. Dezember 1861 in Perleberg geboren. Nachdem er in Berlin, Würzburg und Kiel studiert hatte, promovierte er 1884 in Kiel auf Grund einer damals preisgekrönten zoologischen Arbeit über die Struktur der Muschelschalen. Dann folgte eine kurze Periode, in der der junge Gelehrte in Kiel und Berlin naturwissenschaftlichen Schulunterricht erteilte. Aber schon bald wurde Dr. W. Herwig, der erste Präsident des Deutschen Seefischerei-Vereins, der später auch der erste Präsident des Conseil International pour l'Exploration de la Mer werden sollte, auf ihn aufmerksam und gewann ihn für die Meeresforschung. Schon 1888 wurde er Leiter der Wanderstation des Deutschen Seefischerei-Vereins und später dessen Generalsekretär. Aus dieser Zeit stammen seine Arbeiten über Sardelle, Garneele, Stint, Finte, Kaulbarsch und Stör. 1892 wurde Ehrenbaum an die damals gegründete Biologische Anstalt in Helgoland berufen, wo er anfangs als Assistent, später als Kustos für Seefischerei bis zum Jahre 1910 tätig war. Gross ist die Zahl seiner in diesen 18 Jahren veröffentlichten Arbeiten, von denen wohl sein Beitrag zur Sammlung "Nordisches Plankton", der unter dem Namen "Eier und Larven von Fischen" erschien, ferner seine Arbeiten über den Hummer und die Makrele die hervorragendsten

waren. In dieser Zeit wurde Ehrenbaum zweimal, 1893 und 1904, von seiner Regierung zum Studium der Weltausstellungen von Chicago und St. Louis in die Vereinigten Staaten entsandt. Bald nach Gründung des Conseil International pour l'Exploration de la Mer gewann man ihn auch dort als Mitarbeiter und übertrug ihm später die Generalberichterstattung über die Makrele.

Im Jahre 1910 erfolgte seine Berufung nach Hamburg als Leiter der neu eingerichteten Fischereibiologischen Abteilung des Zoologischen Instituts. Wieder wandte er seine Arbeit der Fischfauna des Unterlaufs der Elbe und der Nordseeküste zu, mit der er 1888 seine Tätigkeit als Fischereibiologe begonnen hatte. Schon bald zeugten Arbeiten über Flunder und Aal von den Fortschritten dieser Forschungen. Während des Krieges erschienen, angeregt durch eine fischereiliche Tätigkeit des Unterzeichneten in Konstantinopel im Jahre 1916, eine längere Darstellung der "Seefischerei in den osmanischen Gewässern". Auch beschäftigte sich der Forscher in den Jahren 1915 bis 1917 auf Veranlassung des Unterzeichneten eingehend mit der Verwendbarkeit des Ottesen-Gefrierverfahrens für Fische, über die eine grössere Arbeit veröffentlicht wurde.

Im Jahre 1920 wurde der Forscher Mitglied und 1929 stellv. Vorsitzender der damals rekonstruierten Deutschen wissenschaftlichen Kommission für Meeresforschung, und, nach dem Wiedereintritt Deutschlands, deutscher Expert beim Conseil International pour l'Exploration de la Mer. Seine Tätigkeit in den letzten 10 Jahren liegt so vor unserer aller Augen, dass sie hier im einzelnen nicht dargestellt zu werden braucht. Dies um so weniger, als glücklicherweise sein Ausscheiden aus dem Staatsdienst nicht gleichzeitig den Abschied aus der deutschen Kommission und dem Conseil International bedeutet. Wir dürfen vielmehr damit rechnen, bei der grossen körperlichen und geistigen Frische unseres lieben Kollegen, der am 20. Dezember 70 Jahre alt wird, noch länger mit ihm zusammenzuarbeiten.

Hamburg, Oktober 1931.

Dr. H. Lübbert.

2.

The Marine Biological Laboratory at Low Isles, N. Queensland.

In the concluding paragraph of his very kind review of my book, "A Year on the Great Barrier Reef", in this Journal (Vol. VI, p. 301), Dr. Th. Mortensen expressed the hope that one of the results of the Great Barrier Reef Expedition might be "the establishment of a per-

manent biological laboratory on one of the coral islands, giving access there for biologists, who cannot afford a great, costly expedition, to see a coral reef and work there under modern laboratory facilities".

One of the most gratifying results of the Expedition was the interest it aroused in marine biology in Australia in general and in the State of Queensland in particular. This interest was given practical expression in the formation at the conclusion of the Expedition of a permanent Marine Biological Service by the Queensland Government. Mr. F. W. Mooreouse, a graduate of the University of Queensland and a member of the Expedition, was placed in charge of this Service and given scientific assistance. As a result of this fortunate development, the huts on Low Isles, all equipment and the scientific library which had been accumulated for the purposes of the Expedition, were handed over to the Queensland Government, and thus formed the nucleus of the first permanent marine laboratory to be established in Australian waters.

A full account of the configuration and position of Low Isles, 16°23′ S. and midway between the inner side of the Great Barrier and the mainland, here some 14 miles apart, and of the adjacent reefs has been given in scientific publications both in Great Britain and Australia (Yonge, 1930, 1931) as well as in my popular book. Details as to the huts on Low Isles and the equipment are also given, but the most convincing evidence of their adequacy is provided by the scope and results of the work of the Expedition during the thirteen months (not eight months as Dr. Mortensen states in his review) it spent on Low Isles. A dinghy and a "flattie" are available for work around the island, while powerful boats can be hired for cruises to distant reefs.

The Low Isles Laboratory is, I think, the fifth marine station to be instituted in coral reef seas, its predecessors being Tortugas and Bermuda in the Atlantic and Honolulu and Batavia in the Pacific. But Low Isles has important advantages over most of these. Both Bermuda and Honolulu are too far north to support more than a limited coral fauna, adequate for experimental and observational work on individual corals but not for large-scale observations, such as we endeavoured to initiate at Low Isles, on the conditions controlling the formation and maintenance of coral reefs. The Tortugas Laboratory is only open during the summer months. Batavia and Low Isles are thus the only marine laboratories within coral reef seas where work can be carried out throughout the year and where there is also an abundant and typical coral reef fauna. The laboratory which Dr. C. Crossland is at present establishing in the Red Sea will add a similar station in the Indian Ocean.

No marine laboratory ever established has, however, been provided

from the beginning with such a wealth of fundamental data as will the Low Isles Laboratory when the Scientific Reports of the Expedition have been published in full by the British Museum (Nat. Hist.). Weekly stations taken within the Barrier throughout the year resulted in complete seasonal records of changes in temperature, salinity, phosphate, silicate, oxygen content and hydrogen ion concentration and also of the nature, abundance and variations in the zooplankton and phytoplankton, being obtained for the waters around Low Isles. A general account of this work has already been published (Russell and Orr, 1931, Russell and Colman, 1931) and the detailed hydrographical and plankton papers are in course of preparation. It can be stated with confidence that no coral island has been studied in greater detail ecologically than Low Isles (Stephenson, Stephenson, Tandy and Spender, 1931), while the biological work there and on the reefs of the Great Barrier was rendered of far greater accuracy and value owing to the co-operation of the Geographical Section of the Expedition (Steers, 1929, 1930, Spender, 1930). The beautiful map of Low Isles prepared by Mr. Spender is of especial value.

The collections of plankton, of reef animals and plants and also of the bottom fauna and flora obtained by dredging and trawling, are in the possession of the British Museum and are at present being investigated by specialists, reports on the Annelida, Enteropneusta, Tunicata. Amphipoda, Xenidae and Hydroida, having already been published. When these reports have been completed the Low Isles Laboratory will be provided with a Fauna List which under ordinary conditions would have taken many years to compile. Finally there is a wealth of information about the breeding, development, growth and life history of corals and other typical inhabitants of reefs, and observational and experimental work on corals, notably the effect of sediment upon them and studies on the physiology of nutrition and the significance of their relationship with zooxanthellae, much of which is already published, and which will also, it is hoped, form the nucleus of further work on these and allied subjects.

The Low Isles Laboratory is under the general supervision of the Great Barrier Reef Committee at Brisbane, Australia, and anyone desiring further information or wishing to work at the Laboratory should communicate with the Chairman of the Committee, Professor H. C. Richards, D. Sc., Department of Geology, University, Brisbane, Queensland, Australia. The Committee are very anxious that the presence of the Laboratory and the nature of its facilities for marine biological research should be widely known and will be delighted to do all they can to assist anyone who wishes to work at the Laboratory, while the wide

experience of Mr. F. W. Moorhouse will be available to all such workers. It may be of assistance to many, however, to know that work on the surface of the reefs is almost impossible (except by means of the diving helmet) by day during the southern summer (November to March) owing to the fact that the day low spring tides are very poor. Exactly the opposite conditions prevail, however, in the winter months (May to August particularly) when the night low spring tides are very poor but the day low tides exceptionally good. Moreover the climatic conditions are then much more pleasant.

References.

Russell, F. S. & Colman, J. S. 1931. The Zooplankton. I. Gear, Methods and Station Lists. Great Barrier Reef Expedition 1928—29, Sci. Repts., Brit. Museum (Nat. Hist.), II, pp. 5—35.

Russell, F. S. & Orr, A. P. 1931. The Work of the Boat Party. Ibid, II, pp. 1—4.

Spender, M. 1930. Island-Reefs of the Queensland Coast. Geog. Journal, LXXVI, pp. 193—214 & 273—297.

Steers, J. A. 1929. The Queensland Coast and the Great Barrier Reefs. Geog. Journal, LXXIV, pp. 232—257 & 341—370.

Steers, J. A. 1930. A Geographical Introduction to the Biological Reports. Great Barrier Reef Expedition 1928—29, Sci. Repts., Brit. Museum (Nat. Hist.), III, pp. 1—15.

Stephenson, T. A. & A., Tandy, G. & Spender, M. 1931. The Structure and Ecology of Low Isles and Other Reefs. Ibid, III, pp. 17—112.

Yonge, C. M. 1930. Origin, Organization and Scope of the Expedition. Ibid, I, pp. 1—11.

Yonge, C. M. 1931. The Great Barrier Reef Expedition, 1928—1929. Repts. G. Barrier Reef Committee, Brisbane, III, pp. 1—25.

In addition to the above much information about the Great Barrier Reef, particularly of a geographical and geological nature, will be found in the three volumes of Reports published by the Great Barrier Reef Committee at Brisbane. Up to the present nineteen papers have appeared in the Scientific Reports of the Expedition published by the British Museum (Nat. Hist.), namely Vol. I, nos. 1—7 (account of the Expedition and physiological researches), Vol. II, nos. 1, 2 (plankton and hydrographical researches), Vol. III, nos. 1—4 (ecological researches, etc.) and Vol. IV, nos. 1—6 (systematic zoology and botany).

C. M. Yonge,

Leader, Great Barrier Reef Expedition, 1928—29.

3.

Referring to his article on "Current observations at Horn's Rev, Varne and Smith's Knoll in the years 1922 and 1923" (J. du C., V,1), Dr. A. T. Doodson, Liverpool Observatory and Tidal Institute, Birkenhead, has sent the following information:—

In the course of this work we find that we had overlooked the fact that at the Varne in 1922 the times of observations were in Summer Time and not in Standard Time. The harmonic constants already published (Journal Vol. V, No. 1, 1930) should be amended as follows: Page 29, Table IVb, E1922 and N1922, decrease the values of k by 6° for K_1,P_1,O_1, by 13° for S_2,M_2, and by 25° for MS_4; Page 31. Varne 1922, decrease k by 13°.

4.

We are informed by Mr. Joseph Borowik, Director of the Baltic Institute, that his laboratory is being removed from Bydgoszcz to Gdynia, the new address being as follows:—

The Director,
Baltic Institute,
c/o Marine School,
Gdynia,
Poland.

Reviews.

Alphonse Berget. Leçons d'Océanographie Physique. 1re Partie: Généralités— Océanographie physique. Annales de l'Institut Océanographique. N. S., Tome IX. Paris, 1930. Pp. 352, 140 Text-Figures.

This book contains 13 chapters dealing with these matters: Cosmogony and geodetics; composition and salinity of sea-water; metrical and dynamical units employed in oceanographic research; sea-level; density and compressibility of sea-water; sound waves in sea-water; luminous waves in sea-water; oceanic soundings, echo-soundings, ultra-sonic soundings; soundings in relation to geophysics; physical properties and temperature of sea-water. It is thus purely physical in treatment, — not in the least hydrobiological. The treatment of the physical matter is admirable; it is full and (as one expects from a French author) eminently clear and interesting. Particularly is this the case with regard to the newer methods of making oceanic soundings without wires. This is quite the best account of these methods that has been published. The mathematical treatment of currents associated with the name of Bjerknes is very lightly dealt with. So is the problem of sea-level (which is so well written about by H. A. Marmer). Tidal theory is hardly touched upon. But all the well-known parts of physical oceanography are very well done.

The least satisfactory part of the book is that dealing with geodesy (and so much of cosmogony as is relevant to geodetical investigation), and oceanography is rather limited in its scope and interest when it tends to neglect recent work in these rapidly changing departments of science, — as our author certainly does in his book. Thus, much of the results of Joly in relation to "magmatic cycles" attributed to the radioactivity of the earth's outer crust cannot be sustained in the light of mathematical-physical criticism. Our information as to past changes in the distribution of land and water on the globe is doubtful in the extreme; hardly any good argument can be made for the existence of the "land-bridges" between the continents which were imagined by the paleontologists, and the hypothesis of "continental displacements" elaborated by Wegener is (as Jeffreys has said) "a migration from the frying-pan into the fire", — a speculation almost devoid of anything resembling proof. Fundamental to all these problems is that of the mode of origin of the earth itself, its hydrosphere and atmosphere and the formation of the shield-regions and geosynclines round about which the continents and oceans have been situated. Some promising

approach to the solution of these problems is indicated by the JEANS-JEFFREYS theory of tidal disruptive encounter (which followed from the planetesimal hypothesis of CHAMBERLIN and MOULTON). M. BERGET, however, does not mention these investigations and deals only with the speculations of ARRHENIUS and some rather pretty (but not even plausible) notions of earth-origin made by M. EMILE BELOT. These latter notions, M. BERGET says, have the merit of reverting to an ancient, essentially French conception, — that of the vortices of DESCARTES. With HELMHOLZ this conception crossed the Rhine into Germany and now it returns in the elegant form of "la balistique cosmique", — doubtless for a very short sojourn. JAS. JOHNSTONE.

J. N. Carruthers. Further investigations upon the water movements in the English Channel. Journ. Mar. Biol. Assoc., N. S., vol. XVII, No. 1. Plymouth, 1930.

In his paper of 1898[1]) GARSTANG expresses the opinion that "the relation between wind action and surface currents is capable of quantitative study". That seems to be obvious, but, in waters moved to and fro by the swing of the tides, as are those of the eastern Channel and southern North Sea, the pioneer should never lose sight of the complexity of the problem. The conditions of the drift in our region are vastly different from those supposed to prevail in a currentless lake with an obliging wind blowing regularly from the beginning to the end of an experimental research.

CARRUTHERS, as an active pioneer of current investigations, is well aware of the very deceptive variations of the two main factors, the direction and velocity of both wind and tidal current. In his new contribution to the determination of the normal régime of the drift in the Channel — North Sea region, he attacks in his usual methodical way a problem that can only be attempted through "a series of steps", among which we may mention the following.

1. A repetition of his 1924 liberations of floaters, for comparison and control of results obtained with different types of bottle and under different conditions of wind.

2. Invention, description and trial of new types of bottle, simple, coupled, or with drags variously disposed, — and comparison of results.

3. Experiments and calculations to work out the speed of floaters carried up Channel by a well recorded wind, in relation with continuous current observations, now made with the author's excellent drift indicator on board the Varne lightship.

4. Attempt to establish a simple equation, based upon the results obtained in 1924, '27, '28 and '29, to express the interrelationship between the mean daily travel of a floater and the corresponding mileage run by up-Channel wind. He proposes $S = \frac{1}{18} \cdot W$, in which S is the mean daily mileage of an ordinary ballasted surface bottle and W the daily mileage of the wind during the same period.

[1]) W. GARSTANG. Report on the surface drift of the English Channel and neighbouring seas during 1897. J. M. B. A., N. S., vol. V, no. 2, 1898.

The short summary given by the author at the end of his text does not give a complete résumé of the work carried out and discussed in this very substantial memoir, full of facts, both technical and hydrographical. We cannot do better for the interested reader than to advise him to read it from beginning to end. We may, however, take upon ourselves to emphasise certain matters, either treated by the author or simply connected with his results, as, for instance, the non-identity of "bottle travel" and "surface current", especially with floaters offering a large surface to the wind. An unballasted bottle is like a sailing ship, and the investigator, like the sailor, ought to consider whether the wind is favourable or contrary to the current, or simply deflecting, positively or negatively, and to measure the angle between wind and tidal current to deduce the true direction of the floater. Continuous observation of the two constantly changing factors, wind and tidal current, being out of the question, one must be content with the resultant of all the agents acting over the period closed by the recovery of an unballasted floater. Ballasted bottles offering as little surface as possible to the wind have been generally employed as a partial remedy for the difficulty. Coupled or drag-bearing bottles are another means to this end. However, in a narrow passage like the Channel, wind and tides ought to be taken into account at least during the first few days of liberation in order to lessen in some measure the error inherent in the assumed direction and velocity of the travel accomplished by floaters.

The duration of action of a wind on the superficial layer of water is also to be noted. A wind just arising may have no translatory effect for a while, a certain lapse of time being necessary before a surface layer is put in motion. One must imagine also that a superficial layer moving under the action of a wind gradually gains in thickness, if the same wind continues to blow. Does the whole mass of water down to the bottom of our shallow seas ultimately run in the direction of that wind and soon form a nearly homogeneous mixture? If it does not, the exchange between Channel and North Sea caused by the action of wind will consist mostly of surface water moving over bottom layers. The friction will cause only a gradual mixing of different waters, and one might conceive that the tongue of "Atlantic" water which periodically enters the Southern Bight remains for a while in the deepest parts of the straits, unaffected by the winds and moved only by the swing of the tides.

These are questions which make the Channel — North Sea region appear an ideal field for experimental research. There is no doubt that Carruthers is now engaged in further investigations with the aid of his drift indicator at different depths which, together with continuous observations of salinity and temperature, are of great biological interest. Gilson.

A. Defant. Die Bewegungen und der thermo-haline Aufbau der Wassermassen in Meeresstrassen. Sitzungsber. d. Preuss. Akad. d. Wiss. Phys.-Math. Klasse. 1930. XIV. Berlin, 1930.

This paper contains a very remarkable contribution to the knowledge of currents in straits. In most straits one can discriminate between a surface current and a bottom current. In for instance the straits of the Dardanelles and Bosporus the surface currents carry light water out of the

straits and the bottom currents bring heavy and salty water into the straits while in Gibraltar and Bab-el-Mandeb the upper currents run in and the bottom currents run out.

DEFANT set himself the task of computing the currents which should be expected theoretically, basing his equation on a series of assumptions which are in close agreement with some of the observed conditions. He obtains a remarkable agreement with the observed character of the currents in the straits of the Dardanelles and Bosporus and arrives especially at the observed inclination of the boundary surface which separates the upper and lower water masses. The agreement is so close that DEFANT can make use of the observed currents and study in detail the coefficient of eddy-viscosity and the coefficient of friction at the bottom. He finds values of the former which agree closely with those which are derived from tidal currents on continental shelves, while the values for the latter come out higher than expected.

The reviewer wishes to remark that DEFANT would probably have obtained a perfect agreement with the observed conditions if he had assumed the coefficient of eddy-viscosity to increase very rapidly directly above the bottom, and the coefficient of friction at the bottom would then be much reduced and could perhaps be neglected. However, the introduction of a variable eddy-viscosity leads to such mathematical difficulties that it is hardly worth while in a case in which simple assumptions gave such good agreement with observed conditions.

The theory also gives very satisfactory results when applied to the currents in the Straits of Gibraltar and Bab-el-Mandeb.

Furthermore, DEFANT examines the influence on the currents and on the position of the boundary surface, separating the two water masses, of a periodic disturbance of the surface, a tidal motion. It is of special interest to note that the tidal wave in the Strait of Gibraltar theoretically gives rise to vertical displacements of the boundary surface of 110 m. while observations from "Michael Sars" and "Thor" indicate displacements of 120 m. and 70 to 80 m. respectively.

The discrepancies between observation and theory can be ascribed to the fact that the theory assumes two bodies of homogeneous water which are separated by a surface of discontinuity, while really both the upper and lower layers are inhomogeneous and a transition layer exists between them. DEFANT concludes by urging a systematic study of the currents in straits according to view-points which are suggested by the theoretical treatment, in order to increase our knowledge of the exchange of waters between the oceans and the adjacent seas. H. U. S.

A. Defant. Bericht über die ozeanographischen Untersuchungen des Vermessungsschiffes »Meteor« in der Dänemarkstrasse und in der Irmingersee. Sitzungsber. d. Preuss. Akad. d. Wiss. Phys.-Math. Klasse 1930. XVI. Berlin, 1930.

This paper gives a very brief account of the expedition of 1929, which has been followed by a similar expedition in 1930. The object of these two expeditions was to investigate in detail an area within which waters of very different origin and characteristic properties occur. Already the first expe-

dition has shown that in Denmark Strait the oceanic polar front is very well developed and that whirls are formed along this front in agreement with the theory of whirls in stratified water. The complete report of the interesting result must be awaited with great anticipitation. H. U. S.

Bjørn Helland Hansen. Physical oceanography and meteorology. Part I (Text), part II (Tables and plates): Report of the scientific results of the "Michael Sars" North Atlantic Deep-Sea Exped. 1910. Vol. 1. Bergen 1931. 114 + 102 Seiten.

Im Jahre 1926 hat B. Helland Hansen zusammen mit Fridtjof Nansen den östlichen Nordatlantischen Ozean auf Grund seiner Fahrten mit dem »Armauer Hansen« in den Jahren 1913, 1914 und 1922 behandelt, in einem Werk, das durch die methodisch mehrfach neue Darstellungsweise, durch die Güte und Kritik des Materiales grosse Beachtung fand[1]). Damals beschränkte sich die Untersuchung auf die Gewässer östlich von der grossen centralatlantischen Schwelle, also östlich etwa von 35—40° W. L.

Das neue Werk Helland Hansens vom Jahre 1930 umfasst beinahe den ganzen nordatlantischen Ozean, in der Hauptsache seine aussertropischen Teile, wobei aber die der Ostküste der Vereinigten Amerikanischen Staaten unmittelbar benachbarten Gewässer noch ausser Betracht bleiben. Diese Ausdehnung oder — wie man will — Begrenzung der Darstellung ist durch das zu Grunde liegende Material gegeben: das norwegische Forschungsschiff »Michael Sars«, auf dem die 3 Meeresforscher Sir John Murray, Johan Hjort und Bjørn Helland Hansen 1910 arbeiteten, überschritt nach einer Reise zur Gibraltar-Strasse, zu den Canaren und den Azoren den 55. westl. Längengrad nicht, indem es schon von Neu-Fundland aus die Heimreise antrat. Gleichwohl kommen wichtige Teile des nordamerikanischen Tiefbeckens und die bekannten schwierigen Grenzgebiete von Golfstrom und Labradorstrom zu einer modernen Behandlung. Wenn auch 20 Jahre seit der Expedition verflossen sind, so ist das neue Buch doch ein sehr wertvoller neuzeitlicher ozeanographischer Beitrag; Helland Hansen benutzt nämlich das ganze auch durch andere Schiffe seitdem hinzu gekommene Beobachtungsmaterial und gibt von der hohen Warte seiner Erfahrungen zur Physik des Meeres viele allgemeine Erörterungen, die ohne weiteres in ein Lehrbuch der Meereskunde übergehen könnten. Diese allgemeinen Abschnitte und die methodisch vielseitigen Karten und Diagramme stellen nach meiner Ansicht zwei wesentliche Charakteristika das Textes und des Atlasses dar. Wir wollen dies durch den Hinweis auf verschiedene Einzelheiten beweisen.

Ein erster Abschnitt handelt von den Eigenschaften des Oberflächenwassers und der darüber lagernden Luft in ihren gegenseitigen Beziehungen. Die grossen thermischen und salinen Änderungen des Meerwassers im 0 m-Niveau sind meist geographisch bedingt. Die kleinen, z. B. täglichen Perioden kann man nicht erwarten von einem fahrenden Schiffe aus korrekt zu erhal-

[1]) Vergl. die Besprechung durch J. R. Lumby im Journal du Conseil, Vol. II. Nr. 1. S. 75—78. Copenhague 1927.

ten, da die Variationen, die man in einem solchen Falle erhält, wesentlich durch die fast überall vorhandene Verfrachtung der Wassermassen (»Versetzung«, »displacement«) erklärt werden müssen. Richtige Werte über die kleinen Variationen wird man deshalb auch nicht von einem verankerten Schiff bekommen, sondern nur von einem ohne eigene Fahrt mit dem Strom treibenden Schiffe. Durch ein geeignetes rechnerisches Verfahren (S. 5) gelingt es aber dem Autor, sein Oberflächenmaterial von den täglichen und sonstigen zufälligen Schwankungen zu befreien und nun auf 4 Diagrammtafeln (S. 76*—82*) für 4 Regionen (Strecke bis Fayal, Sargasso See, Telegrafenplateau und Fär Öer-Kanal) den grossen geographisch bedingten Verlauf der Werte abzubilden.

Nach der Besprechung mehrerer technischer Einzelheiten wendet sich dann Helland Hansen den unter der Oberfläche liegenden Schichten zu, die, mehr oder weniger unbeeinflusst von den meteorologischen Verhältnissen, die Dauerbeziehungen zwischen Temperatur und Salzgehalt im »gewöhnlichen« nordatlantischen Wasser erkennen lassen. Die Konstruktion einer Normalkurve für die Beziehung S/T auf Grund der »Michael Sars«-Beobachtungen bildet den Kernpunkt und Ausgangspunkt für die Mehrzahl der weiteren Abschnitte. Das Diagramm S. 74* hierfür (in Zahlen $S_t = 34{,}737 + 0{,}038\ t + 0{,}0029\ t^2$) gewährt die Möglichkeit, lokalen oder zeitlichen Salzgehalt-Anomalien, wie z. B. dem Mittelmeerwasser im östlichen Atlantik, nachzuspüren, indem man die Temperatur als unabhängige Variable betrachtet, umgekehrt aber auch, bei Festhaltung des Salzgehaltes, ebensolche Anomalien der Temperatur aufzudecken. Hierauf gestützt, kommen hauptsächlich 2 grosse thermische Probleme auf nicht weniger wie 63 Seiten zur Behandlung: 1) die kurzperiodischen Schwankungen von T an einem und demselben Ort bei möglichst stündlicher Wiederholung der Serien, und 2) die Schwankungen im jahreszeitlichen Verlaufe und ähnliche Fragen.

Was das erste Problem betrifft, so lehrt die harmonische Analyse dreier Stationen im Fär Öer—Shetland Kanal, dass auch nach Eliminirung der täglichen und halbtäglichen Periode sehr unregelmässige Rest-Schwankungen übrig bleiben, deren Natur unsicher ist, die aber wahrscheinlich durch die schon oben genannte, nie ruhende horizontale Verfrachtung der Wassermassen zu erklären sind.

Sehr wertvoll sind die Ausführungen über den jahreszeitlichen Temperaturgang jeweils für verschiedene Tiefen von 0 bis 200 m, nämlich im NW von Irland—Schottland, in der Biskaya und westlich von Gibraltar—Marokko. Die so oft gestellte Frage, wie tief die Jahresschwankungen reichen, findet z. B. für die Biskaya die nachstehende Beantwortung (S. 52):

	Min.	Max.	Amplitude
0 m	Jan.	Aug.	7,7
25 m	Febr.	Aug.-Sept.	6,8
50 m	März.	Sept.-Okt.	2,4
100 m	„	Dez.	0,7

Diese Zahlen geben also die Amplitude der Temperatur in ein und derselben Schicht an. An späterer Stelle (S. 83, 84) behandelt der Verfasser

eine ähnliche Frage. Er berechnet—wiederum für die Biskaya — die in verschiedenen Monaten gültige Temperaturdifferenz zwischen je 2 Niveaus, einmal in ihrem Gesamtbetrag ($\triangle t$) und zweitens (als mean variation) den vertikalen Gradienten in $^1/_{100}°$ C. pro ein Meter Tiefenunterschied $\left(10^2 \frac{\triangle t}{\triangle z}\right)$. Diese lehrreichen Differenzzahlen z. B. für die Niveaus 0 m und 200 m sehen so aus:

0—200 m	$\triangle t$	$10^2 \frac{\triangle t}{\triangle z}$
April 18	0.56	—0.3
Mai 14	2.19	—1.1
Juni 8	2.87	—1.4
Juli 18	5.73	—2.9

In zunächst theoretischen Betrachtungen wird auch der Wärmegewinn des Meerwassers durch Einstrahlung (Q_1), der Wärmeverlust durch Verdunstung (Q_2) und durch die langwellige dunkle Strahlung (Q_3) und durch die Konvektion (Q_4) behandelt in der Formel:

$$Q_1 = Q_2 + Q_3 + Q_4,$$

wobei die Werte angesetzt werden wie folgt:

$Q_1 = 275$ g. cal./cm²/24 Stunden
$Q_2 = 120$ —
$Q_3 = 112$ —
$Q_4 = 43$ —

Man kann daher annehmen, dass die tägliche Periode der Wassertemperatur in der obersten Oberfläche auf 2—4° C. steigen würde, wenn die Verdunstung nicht den stärksten Wärmeverlust bedingte, dass anderseits durch die Wellenbewegung die tägliche Wärmeschwankung bis in Tiefen von mindestens 5—10 m übertragen wird, in Tiefen, die sonst davon unberührt bleiben würden.

Selbst den unperiodischen Abweichungen von Jahr zu Jahr in Meerestiefen versucht Helland Hansen nachzugehen und z. B. Unterschiede in der Menge des dem Ozean zugeführten Mittelmeerwassers aus Beobachtungen in der Biskaya der Jahre 1906, 1910 und 1922 festzustellen.

Ein besonderer Abschnitt gilt den adiabatischen Temperaturänderungen in ganz grossen Tiefen, wobei Helland Hansen mehrfach auf die Veröffentlichung des Referenten aus dem Jahre 1914 zurückgreift und verbesserte Tabellen und Diagramme gibt. Was dabei meine Zahlen aus dem Philippinen- und Bougainville-Tief betrifft, so sind weder sie noch die von Wüst 1929 abgeleiteten ganz korrekt, entweder, weil nur Bodentemperaturen recht verschiedener Positionen zu einer »Serie« verkoppelt werden mussten, oder weil die Umkippthermometer des »Planet« jener Jahre vielleicht nicht ganz einwandfrei gearbeitet haben. Wir wissen jetzt — durch die Arbeiten der niederländischen Tiefsee-Expedition auf »Willibrod

Snellius«[1]), was in der Arbeit Helland Hansens noch nicht berücksichtigt werden konnte, aber allgemeines Interesse hat —, dass im Philippinen-Tief keine überadiabatische Temperaturzunahme vorhanden ist; die neuesten Werte sind:

Tiefe	$t°$	$t°_1$	$S\,{}^0/_{00}$	$t°$ = beobachtet.
3500 m	1.585	—	—	$t°_1$ = berechnet ab 3500 m
10030 m	2.485	2.62	34.68	

Im weiteren Verlauf nimmt Helland Hansen auch Stellung zu den von Defant in die Meereskunde übertragenen Begriffen »Troposphäre« und »Stratosphäre«, weist bei der Behandlung des Bodenwassers im nördlichen Nordatlantischen Ozean mit Recht darauf hin, dass direkte Beobachtungen aus der Zeit des Hochwinters in der Nähe der von F. Nansen angegebenen Gegend südöstlich von Grönland ein dringendes Bedürfnis sind, und behandelt endlich die Verhältnisse an der »Demarkationslinie« zwischen Golfstrom und Labradorstrom. Für diese Ausführungen, die in einer Berechnung der unterschiedlichen Tiefenlage (in m) bestimmter Temperaturen gipfeln (S. 82), wäre vielleicht eine geographische Darstellung, wie sie Referent 1902 durch Isothermobathen im »Valdivia« Werk, Band I. Atlas Taf. XXVII versucht hat, noch instruktiver gewesen.

Verhältnissmässig recht kurz (26 Seiten) spricht der Verfasser dann noch über die Salzgehaltsverteilung, über Stabilität und über die numerische Berechnung der Bewegungen der Wasserschichten. Indem er wiederum von der Normalkurve S/T, die den engen Zusammhang beider Elemente repräsentiert, ausgeht und jetzt T als unabhängige Variable benutzt, gelingt es ihm, auch die Salzgehaltsanomalien in ihren örtlichen Besonderheiten aufzudecken und zu erklären. Ein Abschnitt über die an 2 Stationen des »Michael Sars« ausgeführten Strommessungen in der Gibraltar-Strasse und südlich von den Azoren bildet den Schluss.

Am Beginn dieser »Review« war die frühere Arbeit von Helland Hansen (u. F. Nansen) erwähnt worden, die Lumby besprochen hat. Es erscheint zweckmässig, in diesem Zusammenhang auch noch auf J. P. Jacobsen's Contribution to the Hydrography of the North Atlantic (»Dana«-Expedition) hinzuweisen, die 1929 erschien und von B. Schulz in diesem Journal du Conseil 1930, Vol. V. Nr. 2. S. 235 angezeigt worden ist. Die neuzeitliche Meereskunde besitzt nunmehr schon 3 recht umfassende Veröffentlichungen über den Nordatlantischen Ozean, besonders über seinen nördlichen Teil zwischen U. S. A. und Europa. Die heutige Forschung schaut vorwärts und sieht auch nach diesen 3 Arbeiten wesentlich die immer noch vorhandenen ungeheuren Lücken unserer Kenntnisse, regional und zeitlich betrachtet. Diesem berechtigten Standpunkt gegenüber darf aber auch einmal betont werden, welcher enormen Fortschritte sich die Ozeanographie zu erfreuen hat, besonders dank der systematischen Arbeit nordeuropäischer Forscher. Wohin sind die Zeiten, als man vorsichtig und doch unsicher tastend einige wenige Beobachtungen verschiedener Monate, Jahre, Orte zu einem Naturbild versuchsweise zusammenzufassen gezwungen war! Man soll auch dies nicht vergessen. G. Schott.

[1]) Tijdschrift v. h. Kon. Nederl. Aardrijksk. Gen. 1930. S. 717 (1005); 805; 998.

J. B. Tait. The Surface Water Drift in the Northern and Middle Areas of the North Sea and in the Faroe-Shetland Channel. Part I. A Preliminary Report upon the Results of Scottish Experiments with Surface-Floating Bottles. 1910—14: Part II, Section I. A Cartographical Analysis of the Results of Scottish Surface Drift-Bottle Experiments commenced in the Year 1910. Fisheries, Scotland, Sci. Invest., 1930, Nos. II and IV. Edinburgh 1930.

In the first of these two papers, the complete records from the experiments carried out during five consecutive years immediately prior to the War are tabulated, and a statistical analysis of them presented, whilst the second paper deals only with those initiated in 1910. No adequate report upon such an excellent material as was placed in Mr. Tait's hands could have failed to set forth results of great importance, but, as will appear, the author has devised new methods for the treatment of drift-bottle data and has achieved results quite unlooked for. He has, by means of an argument whose precise nature will be indicated below, been able to make inferences of far reaching consequence which have resulted in the amplification of our knowledge concerning the surface water movements of the areas concerned, to an extent quite unexpected. In his first paper he surveys the records (1096 recoveries = 27.3%) resulting from the sending adrift of 4,825 bottles during the five years in question over the northern and middle areas of the North Sea, and that part of the Atlantic Ocean bounded by the curve: — Orkney and Shetland Islands — Faroe Islands — Rockall — the west and north coasts of Scotland north of latitude 57°30′ N; in the second, he studies in very great detail the 303 returns from the 1,109 bottles put out during eight months of the year 1910. The first survey of the data was directed to the obvious end of ascertaining what, if any, broad associations existed regarding liberation areas and stranding coasts. He very soon came to the conclusion that the practice of drawing upon his charts more or less straight lines from points of origin to points of recapture, was of little avail save in some few cases, it being clear that much of great importance and interest was thereby masked. It was noticed that in certain cases where one and the same liberation of bottles had resulted in a number of strandings on a common stretch of beach, the time intervals between the recovery of the fastest bottles and their less speedy fellows, were very suggestive. If the fastest bottles had been picked up after so many days "out", there seemed to have been a lapse of a considerable number of days before further bottles from the same batch were retrieved, and then a further roughly equal time lapse before others were picked up, and so on. The recovered bottles seemed to have gone ashore in batches, and Tait found himself consequently able to assume that practically all bottles from a liberation batch were picked up after lying undiscovered for only a quite negligible time. The periodicity in the incidence of strandings is ascribed by him to the action of some retarding agency situated in the waters between the liberation and stranding positions of the bottles. He is led to invoke the existence of surface water gyrations in this connection, and so to the assumption that laggard bottles owed their lateness in stranding (as compared with their speediest fellows) to a temporary sojourn within the sphere of influence of

some swirl. Having (1) postulated a more or less straight line course for the fastest bottles, (2) estimated the corresponding speed of these latter, and (3) estimated the more or less straight line courses of the laggard bottles independent of their travels within the swirl, he is able to assess the time spent within the swirl by the various batches of these latter. The reasoning is that the second batch of recoveries will have rounded the swirl once, the third twice, and so on. TAIT thus learns how long a bottle takes to perform the circuit of the swirl, and calls the number of days involved "Period of Circuit". In some cases he is able to "adopt" swirls whose existence had previously been inferred by BÖHNECKE; in other cases he invokes swirls whose previous existence had usually been surmised but not established. TAIT regards as perhaps the most significant outcome of his work, the proof of the existence of a large eddy situated approximately between latitudes 57°30′ N. and 61°10′ N. and between longitudes 0° and 3°30′ E. — at least these were its apparent limits in 1910. This large surface water gyration (of counter-clock sense) he calls the "Great Northern North Sea Eddy" and uses the concept most fruitfully in many connections, — sometimes in explanation of the travels of drifters, sometimes in explanation of the vagaries of the flows of water which supply the North Sea from the north.

TAIT reminds us that the large scale investigations upon which he is reporting were in the nature of a pioneering effort and were not conducted according to a prearranged plan such as might now be formulated. Here he rather whets the appetite of the reader whose work lies along similar lines, and who is aware that many drift bottle experiments have been carried out by Scotland almost continuously since 1920. May we not infer that some of these (e.g. those of 1930) were initiated to provide further data bearing upon some of TAIT's more striking deductions? Much of the information derived by TAIT from his studies, concerns a matter of very special interest — the recruitment of the surface waters of the North Sea by way of the northern passages. Much of our knowledge concerning the access of water to the North Sea from the Atlantic has come from plankton studies, and BOWMAN has, in a number of papers (and in his announcement in 1929 regarding the absence of Salps but the presence of other organisms of Atlantic origin previously unrecorded for 25 years), clearly demonstrated the extreme complexity of the water movements in those areas regarding which we now welcome what TAIT has to say. Any information which will, for instance, assist one to understand why "Atlantic Water" bulks largest in the North Sea at a time when the parent supply (the Atlantic Stream) is not flowing at its strongest, is particularly welcome.

Before setting down his own results, TAIT gives an adequate account of the previous state of knowledge, deals with the practical details of the experiments upon which he reports, and describes the bottles used in the Scottish 1910—14 experiments. The latter were 6 oz. square-section bottles weighted by means of lead wound round the neck so as to float just below the surface of the water and thereby escape direct wind influence. The usual postcard was included but no rewards offered to finders. In his account of earlier work, TAIT states, in effect, that if one mapped out the well-known "FULTON Cyclone" from year to year, its southern limits would be much less frequently the chain of Dutch islands than the latitude of the

Great Silver Pit. PETTERSSON's representation (appropriate to summer 1904) and opinions are quoted in support of this view, but, strangely enough, TAIT makes no mention of Admiralty Chart No. 327 whereon is displayed a representation of the surface water movements of the North Sea differing very greatly from the simple FULTON picture. In these differences resides much that is significant but space does not permit the necessary discussion. Suffice it here to say that this chart is much more acceptable than FULTON's, in not displaying the simple concentric stream lines so characteristic of his picture. The fact that both PETTERSSON and RYDER postulated cyclonic swirls of surface water in the middle and northern areas of the North Sea respectively is commented upon, and the agreement of RYDER's view with BROWN's deductions in respect of bottom currents is pointed out. TAIT's reports were prepared before the appearance of CASTENS' recent and suggestive paper (Ann. der Hyd. usw. of February 1931), but it is well worth mentioning that this writer, in the course of an attack upon the hitherto customary method of interpreting salinity charts qualitatively in terms of currents, and of an application in this connection of ideas due to JANKE, has argued that the saline tongue which pushes into the North Sea from the north-west, is probably not indicative, as has been assumed, simply of south-east going surface water. Rather is it to be interpreted, says CASTENS, as defining an area of cyclonically moving water. TAIT might also have referred to the Deutsche Seewarte atlas of salinity etc. for the North Sea. There one sees from the density chart that reason exists to infer a closed counter-clock gyration of surface water in the northern North Sea. The author deals fully with earlier opinion regarding the existence of swirls in the surface waters of the North Sea. However, it might be recalled that SCHUMACHER (Ann. der Hyd. usw. Heft IV. 1923) thought BÖHNECKE to have inadequate grounds for the establishment of a large eddy off the Firth of Forth.

Recalling that by general agreement, the "key area" to the water movements in the northern and middle areas of the North Sea is the region of the Faroe-Shetland Channel, TAIT quotes the views of ROBERTSON and of JACOBSEN and JENSEN, that the main inflow of water enters the North Sea via the Shetland—Scotland passage, and the conflicting opinion of HELLAND-HANSEN, who found that (in one year at least) the main supply came through the Shetland—Norway opening, i. e. "by way of the north of the Shetland Islands". TAIT, who italicises the passage here quoted, refers to the fluctuations in strength of the parent Atlantic Stream, which, we are told, flows in spring or early summer at the speed of some 12 to 16 miles a day and wanes in strength to a daily speed of about 5 miles in autumn or winter — according to investigators who have made this subject their study. He finds reason to urge further investigations upon the strength of the currents in the southern North Sea which are, he says, according to the publications of FULTON and the reviewer, so greatly in defect of the speeds ruling further north. The speeds much in excess of 3 miles a day tabulated in the reviewer's papers can hardly be called "isolated instances", however, nor yet referred to as "apparent". Also, unusually high speeds were not masked by averaging, all individual speeds are tabulated. Cases of drift-bottle travels exceeding ten miles a day occur in papers by GILSON and CARRUTHERS not quoted

by TAIT. However, these (as also TAIT's omission to refer to certain published, albeit sketchily published, data having some bearing on his Great Fisher Bank liberations) are small enough sins of omission. Attention must now be directed to the main results accruing from TAIT's excellent studies. He states that no bottles set away in 1910—14 by the Scottish Fishery Board were recovered south of 53° N. on either side of the North Sea, and consequently considers FULTON's investigations to have been made in a period in some way exceptional in point of surface currents. No recoveries south of 57° N. resulted from liberations made west of the Orkney-Shetland line. The year 1913 witnessed his southernmost recoveries. The Skagerak was most frequently penetrated by bottles during November, December and March. Considering that March is known to be second only to May in point of Baltic outflow strength, this strikes one as a little surprising. Sometimes there is a clockwise surface water eddy round the Faroes. Roughly about Papa Bank there occurs apparently (in summer months at least) a bifurcation of an east-going surface current which is here the manifestation of the north-easterly current from the Atlantic. One branch flows up the west Shetland coasts whilst the other heads into the North Sea between Fair Isle and the Orkneys. Perhaps the former enters the North Sea after rounding the Shetlands. Strong evidence exists that the North Sea receives a greater access of surface waters by way of the Shetland—Norway opening than by the Shetland—Scotland passages. Surprisingly enough there may be an occasional exodus of surface water from the North Sea via the latter — a finding good for more than one year and more than one season. There is too, TAIT finds, an occasional north-going surface current along the eastern (and sometimes the western) shores of Shetland resulting from a flow up the Caithness and Orkney shores which emanates from the Moray Firth area as an escape stream consequent upon unusually great pooling-up there. This pooling-up is due to an extra urge of waters from a north-easterly direction, born of extra strength of that part of the flow into the North Sea via the Shetland—Norway opening (which flow, owing to the situation of the Great Northern Eddy, is greatly restricted in breadth of path) which does not merge with the eddy but bends south-westwards. The north-going stream of Moray Firth origin may inhibit the inflow of surface water from the Atlantic via the Scotland—Shetland passages. TAIT's papers are rich in the presentation of such important findings, and one looks forward to future papers analogous to Part II relative to the other four years. Any doubts concerning the lack of importance of the wind, which might linger in the minds of some readers, could be resolved if TAIT were to make simultaneous liberations of ordinary surface drifters and deep-floating instruments at critical places. Statistically viewed, his derivation of the period 20 days as applicable to the circuit of the North-East Dogger Bank Swirl might perhaps be objected to. Will TAIT be able satisfactorily to reconcile his Great Eddy with isohaline charts; what is happening within this gyration, and may its eastern boundary not define a convergence line? Though quite acceptable as inferred from argued open-sea travels of drift-bottles, one wonders whether the concept of this eddy will remain unassailed in later years. If the area covered by this eddy were occupied largely by south-east going surface water, could the bottle journeys possibly be ex-

plained if the eastern limb were a sharply defined convergence line having north-moving water to the east of it? LUMBY suggests that a crucial test might be provided if it could be learned whether two floats put out in the western limb of TAIT's Great Eddy maintained their same latitude relationship when ultimately floating northwards up the eastern boundary.

One may best indicate the value of TAIT's work by expressing the opinion that his excellent papers will be held in increasing esteem as other workers become more intimately acquainted with their content, which is naturally far from easily mastered. J. N. CARRUTHERS.

Kurt Buch. Über den Einfluss der Temperatur auf die *pH*-Bestimmung des Meerwassers. Merentutkimuslaitoksen Julkaisu Havsforskningsinstutets Skr. No. 61. Helsinki, 1929.

The influence of temperature on the colorimetric measurement of the hydrogen ion concentration of sea water has not hitherto been fully investigated and has presumably been ignored by most workers. In this paper BUCH has examined the various temperature factors and gives equations and tables for making the appropriate corrections. It is necessary when making measurements of the *pH* value of sea water to measure the temperature of the water *in situ* (t_w) and the temperature of the buffer solution (t_p). The correction to be applied to find the *pH* of the buffer at t_p is given in a table. The *pH* of the sea water is then found by the following equation,

$$pHt_w = pHt_p + \alpha(t_w - t_p)$$

where α is the change of the dissociation exponent of the indicator for a temperature change of 1° C. It is obviously most suitable to have the temperature of the buffer the same as that of the sea water *in situ* so that the *pH* value of the sea water is the same as that of the buffer.

If the temperature of the sea water at the time of measurement (t'_w) varies by several degrees from that *in situ* (t_w), the additional correction 0.004 ($t'_w - t_w$) has to be added. The correction to be applied to the buffer solution is only known for temperatures exceeding 10° C.; it should not be allowed to fall below this for measurement.

So far only phenol red, phenolphthalein and naptholphthalein have been investigated. The forthcoming paper on cresol red, which is much more commonly used in the sea, will be awaited with interest.

A. P. O.

H. Wattenberg. Die Bestimmung von Phospat, Nitrat, Nitrit, Ammoniak und Silikat in Meerwasser. Ann. d. Hydrog., usw. LIX Jahrg. H. 3. Berlin, 1931.

The author, who acted as chemist on the "Meteor" expedition in the Atlantic, gives the essentials of the methods of analysis of the minor constituents of sea water which are of great importance for the algal plankton. Though essentials are given, the descriptions are characterised by a commendable brevity. It may be remarked that ferric iron is not a usual constituent of sea water, in quantities sufficient to interfere with the nitrate

test, in shallow waters, yet the possibility of its causing error in oceanic waters should be borne in mind. Some of the findings of Oscar Sund as regards the use of the nitrate method might also perhaps have been mentioned, but as the author was in correspondence with Sund on these points their omission was obviously due to a desire for brevity. A description of the author's useful method for estimating ammonia has been included.

W. R. G. Atkins.

1.) **F. Wenner, E. H. Smith** and **F. M. Soule.** Apparatus for the determination aboard ship of the salinity of sea water by the electrical conductivity method. U. S. Bureau of Standards Journal of Research Vol. 5, Research Paper No. 223. Washington D. C., 1930.

2.) **F. Vlès** et **M. Gex.** Notes sur la technique de dosage électrométrique des chlorures dans l'eau de mer. Bull. de l'Inst. Océanog. No. 566. Monaco, 1931.

1.) The authors of the first paper describe a convenient method and two types of a compact apparatus for the determination of the salinity of sea water by a conductometric method suitable for use on hydrographic surveys.

The Wheatstone bridge method is employed and modified to meet the special difficulties encountered at sea, with due regard to accuracy and ease in working. The bridge is calibrated by using standard sea waters, the salinities of which have been determined in the laboratory. These standard sea waters are contained in one arm of the Wheatstone bridge and the slide wire readings are determined when a constant arbitrary sample of sea water is contained in the adjacent arm.

An empirical equation is then deduced giving salinities in terms of slide wire readings. The salinities of samples of sea water could then be obtained by comparison with this arbitrary constant sample of sea water.

The advantage of this procedure is that the actual temperature of the thermostat is of relatively small importance, as all samples of sea water have practically the same temperature coefficient of resistivity. It is important, however, that the cells in the two arms of the bridge should be at the same temperature. Further, any polarisation effects are largely neutralized, as the polarisation is substantially the same in both cells.

Three adjustments are necessary before taking a reading. A small variable resistance in series with the standard cell is first adjusted so that the same bridge wire reading is observed for a given sample, no matter which of the various sample cells is used. The slide wire on the Wagner branch is then adjusted, the Wagner branch being a device by which the telephone receivers are brought to the same potential as the shield, without being actually connected to it. A third adjustment is then made of the small variable mutual inductance between the leads from the source of the alternating current and the telephone leads. This balances any out of phase components of potential difference in the bridge.

The bridge slide wire is contained between two fixed resistances, each of seven times the resistance of the bridge wire.

The components are arranged in an electrically shielded cabinet, in such

a way as to prevent leakage of sea water or water from the enclosed thermostat, every precaution being taken to ensure that the various resistance coils and slide wires are not liable to corrosion.

The cabinet contains four compartments, in the lower pair of which are situated the microphone hummer, which supplies the alternating current for the bridge, and the enclosed thermostat.

The conductivity cells, which are approximately 10 cm. long and have an internal diameter of 1 cm., give a resistance of about 200 ohms when filled with sea water.

The electrodes are hollow, truncated, platinum cones, which are covered with platinum black. The cells are fastened into the thermostat lid with rubber gaskets which give a water-tight joint. They need not be removed from the thermostat during filling operations.

One of the upper compartments of the shielded cabinet contains the stirring apparatus, relay, and heating lamps for keeping the humidity low, while the other one contains the electrical measuring apparatus.

All the electrical power required is supplied from the ship's 110 volt supply, the voltage being suitably tapped for the various uses to which it is to be put.

Alternative methods of calibration of the bridge wire are described and the method is claimed to give results of equal accuracy to that obtained by the International Titrimetric Method.

An account is given in the paper of an instrument similar in character to that outlined above, which was in use aboard the "Carnegie" research ship during one of its oceanographic surveys.

Recommendations regarding future constructional improvements of the apparatus are given at the end of the paper.

2.) Another method for the determination of chlorine in sea water is described by Vlès and Gex. This method consists of an electrometric titration of sea water. The determination of the total halogen involves the measurement, by means of a potentiometer, of the electromotive force between a silver wire, acting as an indicator electrode, and a saturated calomel electrode as a reference electrode.

The method, as described in this paper, is very cumbrous, and not to be recommended for routine determinations of the salinity of sea water.

E. H. Williams.

H. H. Gran. The spring growth of the Plankton at Møre in 1928—29 and at Lofoten in 1929 in relation to its limiting factors. Skrifter Norske Videnskaps-Akad. 1. Mat.-Naturv. Klasse. 1930. No. 5. Oslo, 1930.

Die neuen Untersuchungen Gran's und seiner Mitarbeiter schliessen sich eng an die früher vor dem Romsdalsfjord und bei den Lofoten gemachten an. (Vgl. Journ. du Cons. Vol. 4 p. 347 ff.). Es wurde bei Møre (Romsdalsfjord) der schon früher bearbeitete Schnitt senkrecht zur Küste über die Küstenbank in besonderer Anpassung an die Diatomeenwucherungen des Frühlings dreimal wiederholt, nämlich vor dem Beginn der Wuche-

rung, zur Zeit ihres Maximums und 3—4 Wochen später. Bei den Lofoten wurde ebenfalls ein Schnitt über die Küstenbank bearbeitet und besonderer Wert auf dessen Vergleich mit dem hinter den Inseln gelegenen Westfjord gelegt. Alle Planktonuntersuchungen waren durch regelmässige Feststellungen über die physikalischen und chemischen Verhältnisse, insbesondere auch über den Phosphat- und Nitratgehalt begleitet. Zur Technik ist zu erwähnen, dass GRAN zur Konservierung des Nannoplanktons in neutralisiertem Formalin übergegangen ist.

Es werden nacheinander die einzelnen Beobachtungsreihen durchgesprochen, wobei das Hauptaugenmerk auf die Feststellung der die Planktonwucherung begleitenden und bedingenden Veränderungen des Nährstoffgehalts gerichtet ist. Darauf folgen, wie in früheren Arbeiten des Verfassers, Mitteilungen über das Verhalten der einzelnen Arten. Hauptergebnisse von allgemeinerem Interesse sind folgende:

Das Plankton in den beiden Untersuchungsgebieten zeigt jährliche Fluctuationen. Wenn schon in den Fjorden die Planktongemeinschaften als stationär zu betrachten sind, und daher auch besonders grosse Aussichten haben, die Frühlingswucherung draussen am Schelfrande zu beherrschen, so können doch andere Arten (z. B. 1927 *Asterionella japonica*), die entfernten Gebieten entstammen, infolge zufälligen Vorhandenseins von Zellen zur Zeit günstiger Bedingungen, dort die Führung übernehmen. Südlichere Planktonkomponenten, die im Romsdalsfjord überwintert hatten, trugen im Frühling 1929 beträchtlich zu der Planktonwucherung bei. Die Untersuchungsgebiete sind im Frühling offenbar für vielerlei Formen verschiedenen Ursprungs ausnutzbar.

Die Beobachtungen bestätigen aufs neue BRANDT's Theorie, dass die Phosphate und Nitrate im Meerwasser der begrenzende Faktor für die Planktonproduktion sein können. Und zwar waren sowohl bei den Lofoten wie bei Møre die Nitrate vorwiegend massgebend. Wenn nun aber der Reichtum an diesen Nährstoffen im Frühling, abgesehen von der Zufuhr vom Lande, durch Konvektion bedingt ist, so bleibt es unverständlich, warum nicht ausserhalb des Schelfrandes und des Küstenstroms im reinen atlantischen Wasser dieselbe Planktonproduktion stattfindet, und warum überhaupt Küstengewässer so viel produktiver sind als der offene Ozean. Noch andere Faktoren müssen also anregend und begrenzend mitwirken. Vielleicht fällt die Menge der als Ausgangsmaterial vorhandenen Zellen ins Gewicht, vielleicht die Zufuhr von Humusstoffen und dergl., sowie von Eisen- und Manganionen.

Eine Bewertung der Gesamtproduktion ist möglich auf Grund von Berechnungen der Zunahme des Sauerstoffs und der Abnahme der Phosphate und Nitrate während der Wachstumsperiode der Diatomeen. Beide Methoden führen im ganzen zu gleichsinnigen Ergebnissen. Sie gestatten die Unterschiede der Produktion in den verschiedenen Beobachtungsjahren festzustellen. E. H.

A. B. Klugh. Studies on the photosynthesis of marine algae. No. 1. Photosynthetic rates of *Enteromorpha linza, Porphyra umbilicalis* and *Delesseria sinuosa* in red, green and blue light. Contrib. Canad. Biol. & Fish. N. S., vol. VI, No. 4. Toronto, 1930.

About half the paper consists of a critical review of previous work upon photosynthesis in various regions of the spectrum.

Pieces of the fronds of *Enteromorpha linza*, a green alga, growing just beneath the surface of the sea, of a red alga, *Porphyra umbilicalis*, of which the brownish red fronds were growing on the side of a dock at half-tide level, and of *Delesseria sinuosa*, a bright magenta-red alga from a depth of 18 metres in Passamaquoddy Bay, were placed in vials of sea water (previously brought to pH 7 by the addition of KH_2PO_4) behind Corning red, green and blue filters, which had been brought to equal intensity in the photosynthetically active part of the spectrum, and exposed to sunshine. The increase in alkalinity, due to the using up of carbon dioxide was determined by observing the pH value with the set of capillary tubes containing standard buffers, and phenol red as indicator, prepared by the British Drug Houses, Ltd., of London. Photosynthetic rates for each species were determined by dividing the gain in pH (in hundredths of a unit) by the time. The photosynthetic rates of these three species in the different regions of the spectrum were different, those of *E. linza* being, red = 1.80, green = 0.16 and blue = 1.16; of *P. umbilicalis*, red, 2.46, green and blue 1.65; and of *D. sinuosa*, red, 1.35, green, 1.25 and blue 1.05. These results fit in well with the transmission coefficients for red, green and blue light in the Bay of Fundy at the place where the experiments were carried on, as green light penetrates best, blue next and red least.

It may be noted that the change in pH value has been used as an index of the carbon dioxide consumption, as over this range the two are proportional; thus the latter is not proportional to the change in the hydrogen ion concentration, but to a function of this, the pH value. The temperatures of the experimental tubes were 25° C. at the start and never rose above 27° C., being the same in all. The adjustment of the filters to equality was made by the aid of a pyrheliometer using neutral tint screens, also a Wratten infra-red (No. 88) filter. It was taken that mid-day sunlight consists of 50% visible and 50% infra-red radiation. W. R. G. Atkins.

A. Krogh and **E. Lange** with **W. Smith.** On the Organic matter given off by algae. Biochem. Journ. Vol. XXIV, No. 6, London, 1930.

Although this paper deals with fresh water algae, the results are of very considerable interest to marine workers. According to Putter's well known hypothesis, aquatic animals of all groups live largely on dissolved organic matter present in the water and this is considered to be derived from the photosynthetic processes of the plankton algae. The object of the present work is to find whether, and to what extent, algae give off organic matter to the surrounding medium. The final solution of such a problem in the sea is not yet possible because of the difficulty of estimating, with even a moderate degree of accuracy, the total dissolved organic matter present. Krogh, however, has described a fairly accurate combustion

method for fresh water (Biochem. Zeit. 221, p. 247, 1930) which surpasses in reliability any methods hitherto available for sea water. His experiments are in two groups; first, on pure cultures of *Scenedesmus obliquus* in artifical media and second, on natural lake water in which the algae were brought to luxuriant growth. In the culture experiments less than 5% of the organic matter formed by photosynthesis was given off to the water while at least 95% was stored in the cells. In the experiments on natural lake water, the amount given off was slightly higher but did not exceed 10%. In the opinion of the authors, even this small quantity (at most 10%) was most probably due mainly to dead and decomposed organisms. The organic substances directly lost during assimilation was thought to be wholly negligible.

The results then are very strong evidence against Putter's statement that 80% or more of the material produced by algae during photosynthesis is given up to the water, though whether different algae vary in this respect remains to be seen. Among marine workers there is still a considerable difference of opinion as to the validity of Putter's hypothesis, which will only be removed as more accurate and reliable methods of analysis become available. The present paper is an important step in that direction.

A. P. O.

W. N. Nikitin. Die untere Planktongrenze und deren Verteilung im Schwarzen Meer. Int. Rev. d. ges. Hydrobiol. u. Hydrog. Bd. 25, H. 1/2. Leipzig, 1930.

Since 1923 a number of periodic cruises have been made in the Black Sea by which a general picture has been obtained of the various hydrographic conditions from the surface downwards throughout the year. During this period plankton catches have been taken in silk townets, vertical hauls being made with Nansen closing nets with which Cori's releasing mechanism was used and horizontal hauls being made by means of a modified model of Giesbrecht's closing net. The depths at which the nets were fishing was estimated by measuring the angle of the towing warp and these depths were checked by the use of Kelvin tubes.

As a result of these collections Professor Nikitin has been able to provide a survey of the lower limits at which the plankton animals can live over the whole of the Black Sea and the results are set out clearly in a map. It is quite evident that this lower limit is determined by the peculiar hydrographic conditions to be found in the Black Sea. In the layers below 50 m. there is a marked rising of all "Isoflächen" as one moves from the coast outwards to the open waters; this contouring is closely followed also by the lower limit of plankton life. Planktonic animal life is practically absent at a depth at which the oxygen is reduced to 5—2%, and at which the temperature varies between 8.55 and 8.65° C., and the salinity is at 21—21.10 ‰. In this layer there are considerable quantities of dead plankton organisms and flocculent detrital matter due probably to a sudden increase in the density and viscosity of the water. Here are also found a few animals which can withstand temporarily the low oxygen conditions and occasional presence of H_2S. These are *Calanus finmarchicus*, *Pseudocalanus*

elongatus, Oithona similis, Oikopleura dioica, Sagitta euxina, and Polychaete larvae, the chief being Polychaete larvae, Calanus and Pseudocalanus.

Of the whole sea surface outside the 200 m. isobath the proportions of the water layers inhabited by plankton animals are as follows, the thinnest areas being in the open sea. From surface to 100—125 m., 20.67%; surface to 150 m. 35%; surface to 175 m. 41.5%; surface to 200 m. 2.5%, and to 225 m. 9.33%. This deepest layer is of interest as being in the neighbourhood of the Bosphorus where the deep Bosphorus current probably brings in water richer in oxygen. F. S. R.

E. Schreiber. Über Reinkulturversuche und experimentelle Auxosporenbildung bei *Melosira nummuloides*. Arch. f. Protistenkunde, LXXIII, Heft 3, Jena, 1931.

Melosira konnte mit gutem Erfolge in Agar-Kulturen gezüchtet werden, im Gegensatz zu anderen Centricae, welche sich auf festem Substrat wegen ihrer dünnen Schale nicht kultivieren lassen. Der Einfluss der Intensität des Lichtes auf die Vermehrung von *Melosira* wurde bei künstlichem Licht geprüft. Es zeigte sich, dass diese Art zu schneller Zellteilung mehr Licht nötig hat als *Biddulphia mobiliensis* und weniger Licht gebraucht als die Chlorophycee *Carteria*.

Das Volumen der aus der Mutterzelle austretenden Auxospore kann durch Erhöhung der Salzkonzentration des Seewassers künstlich verkleinert werden, doch zeigt die Auxospore die Tendenz, die für die Art spezifische Grösse wiederherzustellen. Die Bildung von Auxosporen kann durch Überführen der *Melosira* in Nährlösung von stärkerer Salzkonzentration gehemmt (die Zellen setzen dann die einfachen Zellteilungen bis unter die normale Minimalgrösse der Art fort), durch Einwirkung geringerer Konzentration dagegen gefördert bezw. hervorgerufen werden. Dabei ist aber nicht der absolute Grad der Salzkonzentration wirksam, sondern die Veränderung gegenüber dem Ausgangsmedium. Eine in einer Nährlösung von 4 % Salzkonzentration gezüchtete Kultur bildete nach Überführen in 4,5 % und 5 % zunächst keine Auxosporen; eine in 6 % Salzkonzentration gehaltene Kultur ging aber in 5 % und 4 % zur Auxosporen-Bildung über. Auch in freier Natur scheint geringe Salzkonzentration die Auxosporen-Bildung zu fördern.

Zum Schluss wird die Auxosporen-Bildung bei *Biddulphia sinensis* beschrieben. Künne.

H. Blegvad. Quantitative Investigations of Bottom Invertebrates in the Kattegat with special Reference to the Plaice Food. Rep. Dan. Biol. Stat. XXXVI, Copenhagen, 1930.

Die quantitativen Untersuchungen der Bodenfauna, die »Bonitierungen« im Kattegat wurden in neuerer Zeit in der Weise ausgeführt, dass die Stationen in Reihen (»Schnitten«) angeordnet wurden, wobei jeweils nur 1 oder 2 Proben mit dem Petersen-Greifer genommen wurden. Jeder Schnitt liegt innerhalb eines und desselben Biotops (die Einteilung der Tiergemeinschaften ist die von C. G. Joh. Petersen). Bei den Untersuchungen des Magen- und Darminhalts der Schollen wird eine neue Gewichts-Schät-

zungsmethode beschrieben, welche weniger zeitraubend ist als die Auszählung der Stückzahl der Nahrungstiere. Blegvad nimmt an, dass das Gewicht des Mageninhaltes bei gleichaltrigen, zur Tageszeit am selben Platz gefangenen Schollen proportional der Anzahl der Schollen ist. Drei Grössengruppen der Schollen (0-Gruppe, I-Gruppe und II-Gruppe + ältere) werden unterschieden und getrennt bearbeitet; der gesamte Mageninhalt einer Schollenprobe wird sortiert, der procentuale Gewichtsantail einer jeden gefundenen Nährtierart wird geschätzt. Die einzelnen Werte werden (als Bruchteile von 1) mit der Anzahl der untersuchten Schollen multipliziert, das Produkt ist der »Gewichtsindex« der Nährtierart in der untersuchten Schollenprobe. Bei mehreren gleichartigen Fängen ergibt die Summe der Indexziffern den Totalindex der Art (als Ausdruck der »Abundanz« im Schollenmagen), während die Zahl der Fänge, in denen die Art vorkommt, eine Vorstellung von ihrer »Frequenz« gibt. Die Indexziffern erleichtern den Vergleich zwischen Bonitierung und Nahrungsuntersuchung. Da alle Schätzungen bei der letzteren von Blegvad selbst vorgenommen wurden, ist die Genauigkeit völlig ausreichend.

Von allgemeiner Bedeutung ist ferner die Einteilung der Bodenfauna nach dem Grade, in dem die einzelnen Arten von der Scholle als Nahrung begehrt sind. Blegvad unterscheidet Schollennahrung 1. und 2. Klasse, ausserdem eine dritte Gruppe von Bodentieren, welche überhaupt nicht von der Scholle gefressen werden. Eine Liste der wichtigsten Arten (S. 11) erläutert diese Einteilung, die auch in den Bonitierungslisten berücksichtigt wird.

Die Auswertung der 8 ausführlichen Bonitierungslisten und der 5 Tabellen über die Schollennahrung bringt neben den speziellen, für das Kattegat und seine verschiedenen Teile wichtigen Angaben noch eine bemerkenswerte Fülle von ökologischen Einzelheiten, von denen hier nur einige herausgegriffen werden können.

Die kleinen Schollen der 0-Gruppe ernähren sich hauptsächlich von pelagischen kleinen Crustaceen, haben also keine Beziehungen zur Bodenfauna. Bei den älteren Schollen überwiegen in allen Tiergemeinschaften die Würmer, welche 50—80 % der Nahrung ausmachen. (Eine Ausnahme wurde auf einem Schnitt der *Amphiura-Filiformis*-Gemeinschaft im westlichen Kattegat beobachtet, wo infolge der »Beliebtheit« von *Cultellus pellucidus* die Muscheln überwogen.) Auf den Jungfischgründen spielt *Nephthys hombergi* eine grosse Rolle; die kleineren Schollen hatten viele Hinterenden, die grösseren ganze Stücke von *Arenicola marina* gefressen, welche Art vom Bodengreifer nicht erfasst wird. Sonst stimmen die Bonitierungslisten im grossen Ganzen mit dem Mageninhalt der Schollen überein. Die Tatsache, dass die Würmer auch dann im Mageninhalt überwiegen, wenn sie in den Bonitierungslisten zurücktreten, erklärt Blegvad damit, dass die Schollen den Bestand dieser von ihnen so stark bevorzugten Tiere niedrig halten. Andere Abundanz-Unterschiede einzelner Arten lassen sich aus dem Umstand erklären, dass die Bonitierungen zu einer anderen Jahreszeit vorgenommen wurden wie die Nahrungsuntersuchungen. Wir kommen damit auf die jahreszeitlichen Unterschiede der Gemeinschaften, auf die »Aspektfolge«. Gute Beispiele dafür sind das alljährliche Auftreten der 0-Gruppe von *Spisula subtruncata* von Juni an und die jungen *Pectinaria*

koreni im Spätsommer, beide in der *Venus*-Gemeinschaft. (Anm. d. Ref.: Bestandsschwankungen einzelner Arten konnten wohl nicht festgestellt werden, weil keine terminmässigen Beobachtungen vorlagen?)

Bezüglich der Jahresproduktion der Bodenfauna im Kattegat betont Blegvad, dass wir durch einzelne Bonitierungen, welche nur Augenblicksbilder liefern, keine Zahlen für die Mengen erhalten, welche im Laufe eines Jahres wirklich erzeugt werden. Wir müssten mindestens noch die Mengen hinzuzählen, welche von den Schollen verbraucht werden. Nur aus der Ökologie einiger Arten können wir einige Schlüsse auf die Produktion ziehen. Auf den Jungfischgründen im westlichen Kattegat enthält die Gruppe »Schollenfutter 1. Klasse« viele schnellwüchsige, zum Teil einjährige Arten, andere, wie z. B. *Ampelisca*, pflanzen sich wahrscheinlich mehrmals im Laufe des Sommers fort und entwickeln mehrere Generationen; daher ist hier die Jahresproduktion sicher sehr viel grösser als der Augenblicksbestand. Die Arten derselben Nährtiergruppe im östlichen Kattegat wachsen zum Teil langsamer und sind langlebiger, sodass bei ihnen wohl Produktion = Augenblicksbestand ist, während wohl bei der Gruppe »Schollenfutter 2. Klasse« des östlichen Kattegats die Produktion etwas geringer ist als der Augenblicksbestand.

Die Rohgewichtsmengen der Nährtiere 1. Klasse werden für die ganze Fläche des Kattegats berechnet; der Jahresertrag der Dänischen Schollenfischerei wird damit verglichen. Nimmt man mit Petersen an, dass 18 kg (Rohgewicht) Nährtiere 1 kg Schollenfleisch erzeugen, so genügen die Mindestmengen der jährlich erzeugten Nährtiere 1. Klasse bereits, um eine 6mal grössere Menge von Schollen aufwachsen zu lassen, als zur Zeit im Kattegat gefangen werden. Berücksichtigt man ausserdem noch das Schollenfutter zweiter Klasse, so wird der Überschuss an Nahrung noch viel grösser. Blegvad schlägt vor, die Schollen auf den Jungfischgründen im westlichen Kattegat zu schonen, damit sie heranwachsen und nach den tieferen, fast nicht ausgenutzten Gründen des östlichen Kattegats auswandern können. Eine Übervölkerung der Jungfischgründe ist bei dem grossen Nahrungsreichtum nicht zu befürchten.

Sowohl durch das reiche Tatsachenmaterial, wie auch durch die Methodik der Untersuchung und Auswertung gewinnt die vorliegende Arbeit Blegvad's grundlegende Bedeutung für ökologische und fischereibiologische Fragen.

Für spätere, ähnliche Untersuchungen wäre es nur erwünscht, dass die Nahrungsuntersuchungen gleichzeitig mit den Bonitierungsarbeiten ausgeführt werden. A. Hagmeier.

Helen I. Battle. Effects of extreme temperatures and salinities on the development of *Enchelyopus cimbrius* (L.) Contributions to Canadian Biology and Fisheries. New Series. Vol. V. No. 6. Toronto, 1929.

In this publication Miss Battle has set out to study the effects of varying temperature and salinity conditions on the normal development of the eggs and early larva of the four bearded rockling, *Enchelyopus cimbrius* (L). There were two ends in view, firstly to find to what degrees and under what conditions these two factors may be instrumental in bringing

about abnormal development, and secondly how such abnormalities are brought about.

As an aid to further investigation the author begins by describing ten well defined and successive stages of development starting from the unsegmented egg and ending with the newly hatched larva up to the period when the mouth is just open. It was also found that the ranges of temperature and salinity under which normal development can take place were from 13° C. to 19° C. and from 18.6‰ to 45 ‰. It is interesting then that many rockling eggs are spawned in Passamaquoddy Bay at temperatures below 13° C. which in consequence never develop.

Normal ova were subjected to ranges of temperature varying from 0° C. to 35° C., and to salinities between 5.6 ‰ and 80 ‰. Experiments were made by varying the salinities at constant temperatures; by varying the temperatures at constant salinities; and by varying salinities and temperatures during the course of development. From the many experiments the author brings out the following points.

While the salinity range for normal development is 18.6‰ to 45‰, the hatching rate falls off above this range and also below it; but there is evidence that in the lower salinities the musculature is poorly developed and late hatching is due to inability to rupture the egg membrane.

At normal temperatures Q_{10} for hatching and for duration of life lies between 2 and 3; values for Q_{10} are given up to 35° C. which show that from about 25° C. the temperature coefficient is very high, and probably comparable in magnitude to those for coagulation of proteins.

Temperatures and salinities outside the normal ranges tended to produce certain well defined abnormalities. Usually they fell into two categories: (1) the pericardial cavity became enlarged to varying degrees, and (2) the body showed such deformities as a humpbacked condition or a deformed tail. Various other abnormalities were seen but the above two definitely predominated. It was found that the same types of abnormality could be produced either by varying the salinity or by varying the temperature. The author adduces this as evidence that abnormalities due to unfavourable salinities are not osmosis effects.

Certain stages of development are more susceptible to unfavourable conditions than others; it was found for instance that the lethal temperature was lowest for the early blastodermic stages of the eggs when these were subjected to gradually rising temperatures above 15° C. Owing to these critical points in development it was found that if eggs were developed beyond these stages in favourable conditions and then transferred to unfavourable conditions the chances of survival were greater.

The author upholds the view throughout that the abnormalities produced are a result of upsetting the metabolic rates, each organ having its normal rate of development. Following the views of Child she examined dead larvae and found that there were definite starting points for disintegration, and that such occurred also in the egg stage. "Metabolic gradients" were adduced, and the relative susceptibility to KCN tested. It was indicated that there were two gradients of metabolic activity: (1) in the larval tail proceeding anteriorly; (2) in the region of the fore-brain and the pericardial cavity, proceeding posteriorly.

While one must admit that the whole question of "metabolic gradients" still remains controversial, the author has nevertheless succeeded in obtaining interesting data on the effects of extreme temperatures and salinities on the developing rockling egg. F. S. R.

A. Bückmann. Die Überwachung der Alterszusammensetzung des Schollenbestandes in der Deutschen Bucht mit besonderer Berücksichtigung des Fluktuationsproblems. Berichte der deutschen Wiss. Komm. für Meeresforschung. N. F. Bd. V, Heft 3. pp. 112—125. Berlin, 1930.

We have here an admirable review of the German Investigations on Plaice in so far as they relate to the fluctuations of the stock in the German Bight.

If I understand Dr. Bückmann rightly, his objects in writing this article were to collate the whole German material available from 1905 for the study of fluctuations, hitherto scattered in various publications; to indicate to what extent the results obtained from this material agreed with those of other investigators; to show how much light has been thrown on the problem of fluctuations, and finally, to appeal for an extension of the work in order to increase its value.

He has shown that the work of the English and German investigators is in complete agreement; they both show the same rich and poor year classes and have reached the conclusion that the relative frequency of a year class can be judged best by comparison between the relative proportions of the III group with the years groups immediately above or below it when dealing with fish taken in the ordinary trawl. Since the work has been carried out quite independently, it would seem that the methods are sound.

When we turn to the question as to what extent the work throws light on the question of fluctuations, Dr. Bückmann has summarised the present position well in the statement "the positive or negative variations of a year class may be recognised from its relative part in the stock, only in really extreme cases" (p. 114). In this lies the main difficulty of the work. When two or three year classes are all moderately abundant, one will appear to be much richer than another in any one year for various reasons; it may be due to the selective action of the trawl (though this may be overcome to a considerable extent by the use of a cover of fine shrimp-net); again the migrations of plaice vary in the same season in different years; the older fish may have moved off the area investigated or the younger ones have moved in to it earlier or later in one year than in another. For example, after the very cold winter of 1929, the English marking experiments showed that the plaice moved further inshore instead of offshore in May and June, doubtless owing to the fact that while the deeper water remained cold till well into the summer, the shallows speedily became warmer. This example helps to confirm Dr. Bückmann's opinion that "only a large number of catches distributed evenly over a large area can produce reliable material and the effects of weather, sea conditions etc. upon the determination of the density represents another source of error, the effect of which cannot be disregarded".

While Dr. Bückmann has shown, beyond doubt, that the plaice stock is subject to marked fluctuations, it has not been possible for him to obtain material which would enable him to show this effect on the commercial catches. This can probably only be done if statistics of the quantity of each age group of plaice caught per unit of time can be obtained from the actual landings. Here the reviewer would like to support Dr. Bückmann in the plea for an augmentation of the work which promises to furnish a means whereby the problems relating to the effects of fishing on the stock may be solved. D. E. T.-P.

C. F. Hickling. The Natural History of the Hake. Part III. Ministry of Agriculture and Fisheries. Fishery Investigations. Series II. Vol. XII. No. 1, 1930. London, 1930.

This paper is a continuation of that reviewed in Vol. III, No. 2, of this journal, the present instalment being mainly concerned with the seasonal changes associated with the ripening of the gonad as indicated by the weights of the flesh, liver, ovary and testis, the influence of locality on the onset of such changes and the histological condition of the ovary at various stages of its development. Incidentally the author gives an instructive note on the accuracy of weighings made at sea, in which the use of an ordinary extension spring balance has given very satisfactory results, remarkably accurate when tested even in the very heavy weather often experienced. Attention may be called to a few important and to some extent unexpected results which are discussed at some length in the paper.

(a) The male hake matures at about 27 centimetres, and in each successive annual cycle of reproduction the weights of flesh, liver and testis pass from a maximum to a minimum. These weights, expressed as K $\left(= \frac{100\,W}{l^3}\right)$, at their minimum are practically constant for all sizes of fish, but their maximum values increase in a very marked manner, approximately in geometrical progression, with the increasing length of the fish, more so in the liver than in the flesh and much more so in the testis than in the liver. This increasing demand by the gonad on the resources of the male hake, in the author's view, is significant in relation to the small size, rarely over 90 cm., reached by the male, or, as the author expresses it, the metabolic strain on the mature male is a burden which doubles its weight with each 10 cm. increase in length. It would appear from the data given that at this rate of increase a male of 110 cm., if that size were ever reached, would carry a gonad weighing nearly one-third of the weight of the gutted fish.

(b) In tabulating the state of maturity of the female hake, the usual classification into mature and immature proved inadequate, and it became necessary to constitute an intermediate stage, the adolescent, in which the ovary commences to develop, but stops short of producing ripe ova, and at the end of the season regresses to a state equivalent to the spent mature ovary, the developing ova being reabsorbed. The average maximum weight of these adolescent ovaries was only about one quarter that of a fully developed mature ovary in a fish of equal size. These adolescent ovaries showed

a considerable variation in the amount of development which took place before regression commenced and if it had not been for their rosier pink colour, due to their thinner walls, it would not, it seems, have been easy to distinguish by naked eye examination between a large adolescent and a small mature ovary.

The existence of this partial maturation as a normal stage between the immature and the mature ovaries is a novel suggestion, but very convincing evidence of its reality is put forward by Mr. Hickling. Indeed the mere fact that in June the majority of the ovaries of the medium-sized hake are only partially developed, at a time when those of the large fish are ripe, while in October all ovaries are at their minimum size, leaves little room for any other explanation.

(c) The author in an earlier paper suggested that the hake of the Norwegian Deep and the Skagerak formed a distinct stock. He now gives figures to show that these hake have, relative to length, an unusually high body, liver and gonad weight. His suggestion is that possibly the Norwegian hake may grow more slowly in length though not in weight than those from the Atlantic and that the spawning is a function of age and not of body length. Whether this explanation is valid or no it seems clear that the Norwegian and Skagerak hake must be regarded as a separate community. The thorny question of race is not touched on with regard to this question.

In conclusion it may be said that the paper is a notable contribution to an almost untouched side of the biology of the hake. It is based on an enormous number of detailed weighings and measurings which are summed up in the twenty pages which form an appendix. G. P. F.

Aage J. C. Jensen. On the Influence of Hydrographical Factors upon the Yield of the Mackerel Fishery in the Sound. Report of the Danish Biological Station. Vol. XXXVI, Copenhagen, 1930.

This paper investigates, by the use of one of Pearson's formulae, the correlation between the yield of the mackerel fishery in the Sound in different months of the years 1912—1929 and the temperature and salinity of the sea water at surface and bottom in the same and preceding months. The correlation between the yield of certain months and that of other months and of the whole year is also dealt with. Possible causes of the correlations found are investigated, and the biological and practical significance of the correlations are discussed. The main object of the paper is to find a reliable means by which the results of the mackerel fishery in late summer and autumn, the period of greatest yield, may be foretold by previous observations of hydrographical or meteorological conditions in the neighbourhood of the fishery.

The weight of mackerel landed has been used in preference to number, since the former is the less dependent on fluctuations in stock of fish due to good or bad spawning years.

The original statistical data used in this paper are those of the monthly landings of mackerel at Copenhagen, as given in the "Fiskeri-Beretning". The fishery in the Sound is a pronouncedly seasonal one, which takes place chiefly in August, September and October, culminating in September. The

catches landed at Copenhagen are chiefly made with pound-nets in the northern part of Køge Bay. From 1912—1915 returns were given in number, while subsequently to 1915 they were recorded in weight. The returns from 1912—15 are not strictly comparable with the later returns even if reduced to weight, owing to the great variation of the ratio number/weight. I propose in this review to discuss only the data from the latter period and the conclusions drawn from them.

The symbol σ_r is, throughout this paper, used for the "probable error" of the Correlation Coefficient and not, as is more usual, for the Standard Error or Standard Deviation. The criterion used for significant correlation is that $r > 3$ times σ_r.

The relation between the catches in the months July, August and September respectively and the catches in the other months July—October is first investigated, but no definite correlation is shown except between June and July, and it is thus not possible to foretell the results of the main from that of the early fishery.

A very definite connection, for certain months, between the surface temperature of the water, as taken at Drogden L. V., with the catch in the same month, is proved, "r" for September having the value $-.85 \pm .07$ and $-.62 \pm .16$ for October. There is no correlation between the catches and salinity of the water. If the "normal" catch is increased by 10% each year after 1916 to allow for increase of fishing power and the percentage anomalies from this normal are correlated with surface temperature as before, a very high value for "r" in September is obtained, namely $-.95 \pm .03$. Possible causes of the variation in temperature of the surface water are investigated, a very definite connection between surface temperature in August and September with frequency of the west wind in the previous month being proved. Surface and bottom temperatures at Drogden in August and September are also definitely correlated. Air temperature, surface water temperature, and frequency of the west wind also prove to be definitely correlated.

Direct definite correlation between catches of mackerel and meteorological conditions cannot as a rule be shown, these conditions acting on the catches through the medium of surface water temperature.

There appears to be no connection between the quantity of mackerel taken and the quantity of food in the stomachs, the effect of cold surface water in causing the fish to immigrate into inshore waters being a direct one.

The author is of the opinion that the September catch landed at Copenhagen can be forecast with some degree of certainty from observations of the frequency of the west wind in August and from the temperature of the bottom water at Drogden in July and August. This is one of the practical results of the research.

The paper is thorough and the methods used are straightforward and sound. One or two of the values found for the correlation coefficient "r" are so near unity as to suggest a possibility of false correlation. It seems possible that the intense correlation shown between the catches landed at Copenhagen in June and July in the years 1916—29 may be due to some extent to agreement between the members of the pair of high values for

1918. The intimate inverse relation shown to exist between surface water temperature and size of catch in September cannot be explained away on the basis of long period tendencies in temperature and catch. It is the short-period variations in temperature and catch which agree so nearly. Though the use of a varying "normal catch" changes the correlation coefficient from —.85±.07 to —.95±.03, yet the method seems entirely justifiable. The author is to be congratulated on producing results of real practical value to the fisheries, and of easy application. H. J. B.-W.

A. W. H. Needler. The Migrations of Haddock and the Interrelationships of Haddock Populations in North American Waters. Contrib. to Canad. Biol. and Fish. N. S., Vol. VI, No. 10, Toronto, 1930.

To supply the increasing demand in North America for haddock, both fresh and fresh-frozen, a corresponding increasing toll is being taken of the available fish stocks in the waters to the east of the continent. The author of this paper shows that the haddock grounds are of large extent. Even so, we now know that the available supply (from within at least a reasonable range of the chief American fishing ports) is barely sufficient for current requirements, and that frozen cod fillets will require to be produced to maintain fully or to increase a trade which has been fostered on haddock fillets. Either or both of two possible explanations of the growing shortage may be correct. The latter may be coincident with a period when, owing to a succession of less than normally productive annual broods of haddock, the stock is, owing to natural causes, one which is attenuated in numbers. But we know that where a fishery is executed on a stock of older haddock, belonging to quite a series of broods, there is little likelihood of the comparative absence of any one or two broods having a particular effect on the fishing results. And Needler now makes it quite clear that, in the waters whose haddock population he has studied, fish of less than 4 years of age are of no commercial importance, and that only mature haddock in their fifth year or in subsequent years of life are brought to market. Fish of less than 40 centimetres in length are not sought after, whereas in the North Sea, where the maximum possible harvesting of the haddock stock has been reduced to a fine art, the older fish are becoming less and less common, everything above 21 or 22 centimetres in length is brought to market, and the average catch in unit time varies from year to year chiefly in accordance with the degree of abundance of two or three broods of young fish. The incipient apparent shortage in west Atlantic waters must be explained on other grounds, which brings us to consider our second suggestion — that the degree of fishing effort has, owing to the increasing number of trawlers, for the first time passed the point where the stock can annually replace the weight of comparatively large fish which is annually removed.

Organised fishery research in Europe has in the past devoted a vastly greater effort to what may be called the biological or ecological study of the food fishes than to the study of the technical problems concerned in marketing these fishes in such a manner as will make a wider appeal to the potential consumer. As far as the study of haddock in North American waters is concerned the reverse has, until very recently, been the case. New

and improved methods of processing this fish have been developed and promise to be an enduring commercial success. In the form of fresh-frozen fillets haddock are now sold in the interior of the continent, whereas hitherto only a fresh-fish trade proper existed, and this was naturally restricted to the coastal zone near the fishing ports. At the moment the supply of haddock of a size suitable for the new trade is barely sufficient and the fear is gaining ground that the stock is being excessively exploited. An intensive biological inquiry is under foot in the United States with the object of studying the natural fluctuations of the haddock population and the changes which are being brought about in the latter's composition. The idea is that, if there can be produced evidence of progressive diminution of the relative numbers of older fish, the intensity of the fishing effort can be controlled on a rational basis.

NEEDLER, on the Canadian side, has in the above paper contributed many facts which will help to guide the new and more intensive investigations now to be made. For his task he has obtained little aid on the statistical side, for a really good system of collecting statistics, which yield information about sizes, weight and value of fish caught by a known expenditure of fishing effort, is lacking. But he has contrived to show pictorially how the yield of haddock varies on the different parts of the coast. Particularly interesting is his conclusion, confirmed and re-confirmed, that the Fundian and Laurentian gutways subdivide the east North American haddock grounds into three portions containing virtually independent stocks, whose characteristics he describes. In the latter work he is assisted by having at his disposal the results of the first really extensive marking experiments made with haddock. No haddock marked in any one of the three natural areas was recaptured in another area. Seasonal migrations, however, were clearly demonstrated, especially in the Nova Scotian area, where there is a northerly trend each summer with the spread of warmer conditions. The northerly advance is continued — especially in the case of the largest (and, as he shows by scale examination, the oldest) fish — into the Gulf of St. Lawrence, and can be strictly correlated with the spread of suitable temperature conditions. These more venturesome fish are, however, beaten back by the sub-Arctic conditions supervening at the onset of winter — in fact haddock are during the winter season not found north of Halifax, and a large proportion of the shoals seek the still moderately warm layers on the edges of the banks, at below 70 metres' depth. He proves that with increasing age the broods take up a more and more northerly position.

Somewhat analogous movements are shown to exist in the New England region, from which the north side of the Bay of Fundy receives its summer immigrants. The shallow water of this bay — a bay rich in biological interest — provides a narrow passway between the New England and Nova Scotian regions, and a limited amount of interchange of haddock seems to result. Of the stock of the third — the Newfoundland — region, little or nothing is known except that haddock are probably relatively scarce there (except, the reviewer might add, in abnormal years, when they have been known to outnumber cod in certain coastal cod-traps). The author thinks that each of the three regions will yet come to be subdivided into sub-areas each with a more or less distinctive haddock stock, each "community" sorting itself out as a relatively intact entity after such a spell of commingling

as is inevitably caused by seasonal migrations, which are shown to have a scope of anything from 100 to 500 miles.

The conditions of temperature under which west Atlantic haddock live are, season for season, several degrees lower than those found in the North Sea. The range between 2° and 8° is that most favoured. It is unfortunate that the haddock of the Norwegian coast and the White Sea have received so little study, for one would expect to find many parallels between them and those living off the North American coast. The reviewer has seen many scales from haddock of both areas, and has found them to be rather difficult to interpret. Whereas the scale-age of haddock from most other regions can usually be easily determined by examination under water, the distinct impression was formed that those of the two colder regions mentioned should be as carefully mounted as possible. NEEDLER examined his material by placing the dry scales between two slides — a rapid, but not the best method, and one which was largely forced upon him by lack of time. It is to be hoped that part of the material originating from marked and recaptured fish — and therefore especially valuable as a source of facts — will receive a second and an intensive study. On the whole, however, his conclusion that west Atlantic haddock excel in growth rate those of any other region may be accepted as substantially correct. But it must be remembered that only a portion of the material was obtained by the otter trawl, and one would expect, from a wider study of trawled haddock, a general lowering of the figures shown to be attained at each year of age. It must also be borne in mind that most European waters are very intensively fished over and that, at least in the early years of life, the trawl removes more of the better-grown than of the more poorly-grown fish, so that it is the growth rate of the survivors, which had on the whole a slower start, which has been determined. Even allowing for these considerations, however, we must probably agree that European haddock are outgrown by west Atlantic haddock, and therefore that higher temperature in itself is not inducive of faster growth. NEEDLER shows that within the area he has studied the haddock feeding in the St. Andrews region of the Bay of Fundy exhibit the greatest rate of growth. This, he points out, is not because the water temperature there is higher than elsewhere — it is, in fact, exceeded in the Nantucket region — but probably because nutrient salts, the first link in the food chain, are continually renewed in the waters by the mixing caused by the great tides which course over the uneven sea-floor in these parts. It becomes more and more obvious that the biological study of the fish is inseparable from the biological study of the fish's prey, and it is to be hoped that the latter study will bulk largely in the impending haddock investigations in west Atlantic waters. H. T.

R. E. Savage. The Influence of Phaeocystis on the Migrations of the Herring. Ministry of Agriculture and Fisheries. Fishery Investigations. Ser. II. Vol. XII. No. 2. 1930. London, 1930.

This paper gives an account of the distribution of Phaeocystis in the Southern North Sea during three cruises made in April 1924, April 1926 and November 1927, with speculations as to the possible effect that such distribution may have had on the herring fishery in those years. The spring fishery of 1924 was a good one and on this occasion the main efflorescence

of Phaeocystis lay close to the Dutch coast; in 1926 on the other hand, the main body of Phaeocystis was larger and denser and lay more to the westward, occupying about two-thirds of the area between Holland and the East Anglian fishing grounds, and at the same time the fishery was one of the worst on record. It is commonly believed by fishermen that herrings avoid "stinking" or weedy water, and Phaeocystis is one of the main causes of this phenomenon, especially in spring. The author suggests that the distribution of Phaeocystis was such as, in the one case, to concentrate the herrings on the fishing grounds and, in the other, to bar their approach. In 1927, when the important autumn fishery was located far to the eastward of the normal fishing ground, another type of distribution of Phaeocystis, unusual, we infer, both in time and place, though this is not definitely stated, was met with. This consisted of a broad band stretching across the North Sea, to the north of where the fish were found. It is suggested that on this occasion the fish coming from the north met with this obstruction and, passing round its eastern end, did not push on to the usual fishing grounds.

The facts brought forward in the paper are interesting and, as the author says, suggestive, but it is doubtful if they warrant the conclusions, even though qualified as speculative, which are drawn from them as to the influence of Phaeocystis. In fact, apart from the belief of the fishermen that herring are scarce in "stinking" water, no causal connection between the distribution of Phaeocystis and that of the herring shoals can logically be inferred from the evidence adduced. Assuming such a connection, however, it is quite legitimate to speculate, as the author has done, as to how the one event may have affected the other. G. P. F.

B. Storrow. Cullercoats Herring Investigations and their Relation to other Marine Work: An Essay on Fluctuations. Proc. of the Univ. of Durham Phil. Soc. Vol. VIII, Pt. 3. Newcastle-upon-Tyne, 1930.

Mr. Storrow's present work is an attempt to decribe and account for the changes which take place in the herring and other fisheries of the British Isles; his account is a veritable encyclopaedia of events concerning the fisheries during the period 1920—1929, and it would have been beneficial (to the reviewer, at any rate) if the paper had contained maps showing the many areas and place-names with which he deals.

The general plan of the work has been to show that changes in a fishery are accompanied by Atlantic water activity. In 1921 and 1922 there was an unusual flow of Atlantic water into the North Sea by way of the North of Scotland and the English Channel, and owing to peculiar meteorogical conditions caused by this flow, there was a movement to the eastward of a body of mixed water — Atlantic and North Sea — in 1923.

Coincident with these phenomena was the failure of the herring fishery of 1921 and the poor quality of the fish, and in 1922, poor fishing again, and certain changes, including early maturity, formation of new spawning grounds and extended migrations were noticed. In 1923 changes took place in the Baltic fisheries; haddock were caught in large quantities after this year and strange planktonic forms appeared. The size of the Baltic

plaice increased after this year and the Danish mackerel catches were greater than usual. An account of some of the herring fisheries during 1925—8 is given, the outstanding feature of this period being the large catches of three year old fish at North Shields and off East Anglia in 1927. In 1926 Mr. STORROW has deduced, from catches of leptocephali to the west of the Shetlands, and the presence of Ray's Bream in the North Sea, that Gulf Stream water had come through the Faroe-Shetland Channel and coinciding with this flow were increased pilchard catches on Cornish inshore grounds, and increased catches of hake in the North Sea.

1928 saw an increase in the landings at East Anglian ports and good catches were made in Shetland waters, and in the following year, in September, Pteropods were found in abundance off the Northumberland coast, this being taken as an indication of the presence once more of Atlantic water. The East Anglian autumn herring fishing of 1929 began poorly, and Mr. STORROW says that "nothing like the same quantity of herrings were caught in the early part . . . as in 1928," but he makes no reference to the subsequent catches which were much greater than in the previous season.

There is no doubt that had it not been for the disastrous gale of November 11th the year 1929 would have been one of the best years.

The author has certainly given much thought to the causes and effects of water circulation and climatic conditions and changes in the Atlantic and neighbouring areas and the meteorological data which he quotes are so complex that to attempt to condense them into a short review would not be justified.

Apart from the observations on herring the fluctuations of cod, haddock, coal-fish, hake, salmon etc. have been discussed with relation to possible movements of Atlantic water but many of Mr. STORROW's interpretations of tables and figures of commercial catches would not be favourably received if submitted to a small jury of statisticians. The presence of Pteropods, too, off the Northumberland coast, cannot be relied upon to indicate an exceptional inflow of Atlantic water, since the probability of their occurrence off the north east coast in Autumn every year is great.

We are informed that one of the phenomena following a flow of Atlantic water into the North Sea is the early maturity of the herring. That is, large numbers of fish are found maturing at three years of age instead of four. Now, many years ago, Mr. STORROW showed that in samples taken from various places between the southern North Sea and the more saline waters of the north, the age of immature fish increased towards oceanic conditions, in other words, they were slower in maturing in very salt water than they were in less salt water. Bearing this in mind it is not at all obvious that an inflow of Atlantic water into the southern North Sea would bring about the change in maturity as Mr. STORROW says it would. The "change", in the reviewer's opinion, is only an apparent one, and is more likely due to a tremendous increase in the numbers of the year-class of three-year old fish, for the phenomenon mentioned is always followed by a rich year-class.

If this alternative view of the phenomenon is considered one must look for the cause, not during the year during which the three-year old fish are caught, but during the year when they were hatched.

Regarding the presence of uncommon fish one feels that temperature

alone may have an important effect on the extended swimming of these creatures, and that their movements should be used more to substantiate the findings of the Hydrographer than as a means of dispensing with his services.

Although one may disagree with some of Mr. STORROW's interpretations of his material, he is, nevertheless, to be congratulated on making such an effort as this to show a connection between meteorological conditions and our fisheries.

There is an error in Figure I, and Table I. The landing of hake from W. of Scotland in 1928 was 243,000, not 343,000 cwts. W. C. H.

W. F. Thompson, H. A. Dunlop and **F. H. Bell.** Biological Statistics of the Pacific Halibut Fishery. (1) Changes in Yield of a Standardized Unit of Gear. Rep. Int. Fish. Comm. No. 6. Vancouver 1931.

The work of the International Commission which is concerned with the Pacific halibut fishery is of great interest. (A very useful summary of their admirable and successful labours forms No. 7 of this series of reports). The paper under review is concerned with finding and using a suitable measure of catch per unit effort, the method of fishing being baited long lines laid on the sea floor. This is clearly of great importance to us: so far as I know, the only comparable figure we have is the catch per man per day's work used in Norway.

The measure adopted by the halibut investigators is the catch (per one shot) of a line of 300 fathoms length, which is called a "skate". The skate is at present made of 6 pieces of line, each 50 fathoms long, and is furnished with hooks on 5-foot snoods (called "gangings"). The snoods are spaced either 9 feet apart or 13 feet apart; and the effect of this difference has been one of the matters that required investigation. Another similar matter has been a change in the length of a skate, from 400 fathoms to 300 fathoms, which has gradually been in progress since 1913. The skates are laid in a "string", or, as we should say, a "fleet", but it has been the practice of the fishermen to keep a record of the number of skates used at each attempt. Of course the time of "soak", that is the time which the lines are allowed to lie on the sea bottom, varies from ground to ground, and from one occasion to another; but the investigators have deliberately disregarded this factor, and, judging by the homogeneity of their results, there can be little doubt that they are justified in so doing.

The material used throughout the paper consists of the log-book records kept by many of the fishermen, for their own use. It is a tribute to the personality of the investigators that they have obtained access to such a large number of these records, especially when we consider that the information kept by each skipper is in the nature of a trade secret. The number of log-books examined is not given, but in 1928 the investigators had records of the fishing of over 365,000 skates, and even so far back as 1915 of more than 30,000.

Two methodological conclusions are of special interest to us. They are: (1) That the average catch of a skate in a given area and period is unaffected by the number of hooks used, at any rate within the limits set by

the spacing of hooks 9 feet apart as compared with 13 feet. (2) That the yield of a skate is directly dependent on its length. Before going on to examine the evidence for these propositions, let us try to visualise the conditions under which they could be valid. It is, for example, clear that (1) would be invalid, were the fish so dense that there was competition among them for the bait; and, conversely, we may say that (1) is most likely to be valid when the number of hungry halibut is much less than the number of baits. The investigators say that the habit of the halibut is to take a number of baits in succession, until finally it is caught on one of the hooks, this idea being derived from the comparative frequency with which a halibut is taken with several baits in its stomach. That being the case, it is easy to understand that the number of baits is generally in excess of the number of halibut susceptible to them. Considering (2), that the catch is dependent on length of line, though independent of number of hooks, it seems that the halibut must be attractable by a certain proximity of baits to their whereabouts, so that a longer line has a greater chance of being in the proximity of a shoal.

For the sake of brevity we pass over the evidence for these two propositions, merely noting that the evidence for both of them lies in comparison of carefully selected statistics. While this method has the advantage of comprehensiveness (as compared, for example with trial fishing), it leaves room for unknown factors to enter into the explanation of the relations found. (This is recognised by the authors). Nevertheless there can be little doubt that the authors are justified in applying these two principles to their statistics.

The upshot is to demonstrate a marked decline of abundance in all the area fished. The details hardly concern us; but we shall certainly heed the broad fact that fishing with baited lines, a method that we have always regarded as harmless compared with trawling, can result in such a marked diminution, (81 per cent from 1906 to 1928 in one area). What about our European stocks? M. G.

H. Blegvad. Aerial Spotting of Fish Shoals. Danish Experiments in 1930. Rept. Dan. Biol. Stat. Vol. XXXVI. Copenhagen, 1930.

The Danish experiments carried out during 1930, although interesting, differ but little in their results from those already made in other European countries.

A seaplane equipped with wireless and with accommodation for three persons was used. Dr. Blegvad acted as observer.

The flights were made off the east coast of Denmark at two different periods, July 22—28 and September 4—7. Weather conditions were somewhat variable and favourable conditions for observations were obtained in 10 of the total flying time of $17^1/_2$ hours. Flying took place at altitudes between 200 and 400 metres above sea level, and under favourable weather conditions good visibility under the surface was obtained to a depth of 10 metres. During the earlier phase of the experiments no fish or fish shoals were located. In September, however, the results were slightly more encouraging. On one occasion a few large cod were observed over a shallow

area with a sandy sea-floor. On another occasion a few tunnies were recorded, while during the last flight made under favourable flying conditions a large shoal of mackerel was located. The shoal appeared as a narrow belt with a length estimated at 500 metres and a breadth of about 50 metres. Information of the location of this shoal was sent to the National Broadcasting Company. Unfortunately Dr. BLEGVAD does not state whether the information was acted upon or whether the fishermen derived any benefit therefrom.

It is clear from the gradually accumulating evidence from such experiments that the possibilities for the successful use of aircraft in the location of fish shoals is very limited in northern European waters. The chief limiting factor is, of course, the variability of the weather, but even under favourable conditions success with an air machine can be expected only in the observation and location of species which frequent comparatively shallow water or swim in the upper water layers during daylight. Dr. BLEGVAD attributes his lack of success partly to unfavourable weather conditions and partly to a scarcity of herring and mackerel in the shallow or surface water layers. Herring shoals have been located on the coastal fishing grounds at Iceland, and this success is due to a behaviour of the species peculiar to that area, the herring shoals at Iceland rising near the surface at certain periods during the hours of daylight. In European waters, however, this species tends to keep to the deeper water layers by day beyond the range of drift nets which is well beyond the range of vision from aircraft. Mackerel shoals frequently come to the surface water layers and this species may therefore offer further opportunities for search by aircraft.

Although the results of experiments for the location of fish-shoals have been somewhat disappointing it is desirable that such experiments be made, and one readily agrees with BLEGVAD's suggestion that, if the experiments cannot be carried on as hitherto, they may be combined with such fisheries duties as require the use of aircraft. HENRY WOOD.

J. le Gall. La pêche en Islande. Revue des travaux de l'Office des Pêches Maritimes. Tome III, Fasc. 3., No. 11, pp. 213—382. Paris, 1930.

The development of the sea fishery and the necessity of procuring extensive fishing areas has in recent years led to the West-European countries turning their attention, in an ever increasing degree, to the more northern fishing grounds. In the literature on the subject, this development has occasioned in recent years a series of very valuable treatises on the fishery in the northern seas. The treatise before us is an earnest appeal for the resumption of the once so important French fishery in Icelandic waters; the author deals, however, with the fishery in these waters as seen from all points of view, and in his paper he has collected a large amount of matter of value for the elucidation of the whole of this subject.

The fishery-biological conditions in the Icelandic area have, through Prof. JOHS. SCHMIDT's investigations in these extensive waters during the last thirty years or so, been elucidated in manifold ways and the basis of practically all the fishery-biological facts advanced in the present work rely, in fact, on the series of publications issued by SCHMIDT

and his coadjutors on the subject. In this respect a want is, however, still felt of a complete presentment of the biological investigations, embodying also the experience of recent years, and it would be very desirable if Prof. SCHMIDT could find an opportunity to issue a new edition of his classical work: Fishing investigations at Iceland and the Faroe Islands in the Summer of 1903.

After a brief survey of the hydrographical conditions in the waters around Iceland, M. LE GALL gives a synopsis of the species of fish which are fairly frequently to be met with in the area; the species, as for instance cod and herring, which play a leading part in the fishery, being, in this paper, rather thoroughly treated. Illustrations of all species are given, so that the book will be of assistance to those who are not particularly well acquainted with the arctic-boreal fish fauna; a number of the illustrations might, however, have been selected with more care. The synopsis is based to a very great extent on BJARNI SÆMUNDSSON's well known work on the fish-fauna of the area. A chart showing the spawning grounds and migrations of the cod at Iceland and also of the occurrence of herring off the different coasts throughout the year facilitates an understanding of the text. Certain mistakes have crept in; for instance when on pp. 251—252 it is stated that *Pleuronectes platessa* do not undertake great migrations at Iceland, it must be pointed out that as early as 1907 SCHMIDT proved extensive migrations of that species.

In the following section there is a description of the fishery carried on by the Icelanders themselves; this, of course, is concerned chiefly with the cod and herring, the most important species in the area. Clearly and distinctly is to be seen the enormous development that the fishing fleet of Iceland has undergone in the last 25 years or so, in which time a great fleet of fishing trawlers and motor vessels has wrested the chief place from sailing vessels. Both fishing gear and the method of use are exhaustively treated, and the way the fish are dealt with is likewise described. In the chapter "Les résultats", p. 300 et seq. one could have wished for a better, more exhaustive statistical statement on the development of the fishery; a correct impression of the great development which has taken place is not received.

The herring fishery is treated in a similar way to that of the cod; regarding the development of this fishery a comprehensive work is now available, MATTH. ÐORÐARSON: Síldarsaga Íslands, 1930, which will be of value for later works on this subject. The shark fishery and whaling at Iceland is but briefly mentioned.

In chapter IV, pp. 323—355, the fishery carried on by foreign nations at Iceland is then dealt with, and the mention of the French fishery here is of particular interest, as this part contains a great deal of information which hitherto has not been directly available, but which Mr. LE GALL has been fortunate in collecting from sources to which he, as a Frenchman, has had access.

As we know, the French fishery at Iceland had at one time a rich period and, with the author, we may hope that with the help of up-to-date methods this fishery may again flourish. An extract from the tables, p. 324, shows completely the stages of development undergone by the French fishing fleet there.

	French Sailing Vessels	French Trawlers
1870	226	0
1885	314	0
1905	171	12
1914	66	47
1930	22	7

The changes that have occured in the French fishing fleet at Iceland are very distinctly shown by a plate p. 325, and a chart p. 329 shows where and at what time of the year the fishery has taken place. As in the aforementioned section, more thorough fishery statistics would have made this section additionally valuable.

The fisheries of the Faroe islanders and Norwegians are somewhat briefly mentioned, those of England and Germany are treated rather better, but here one misses a survey of the development of the fishery of each individual country partaking in the enormous fishery carried on in these latitudes. After the treatise follows a series of charts which show the fishing grounds for the most important species of fish on all the coasts of Iceland, from month to month.

It may be added that it would have been better had the Icelandic names been more correctly given throughout the work; but that of course is not essential, and besides it is difficult for a foreigner whose language is so far removed from the Icelandic as the French.

The author points out to his countrymen the way in which the French fishery at Iceland might be successfully developed and his experience is sufficient assurance that the way forward to a greater profit for France in these waters lies along the lines indicated by him; it is to be hoped that the great amount of work embodied in this treatise may bring about the progress which the author desires for his nation in this region.

Å. Vedel Tåning.

W. Loftas. Bratfischhandel in Grossbritannien. Handbuch der Seefischerei Nordeuropas. Band IX. Heft. 3. a. E. Schweizerbart'sche Verlagsbuchhandlung. Stuttgart, 1931.

The ninth volume of Lübbert and Ehrenbaum's ten-volume Handbook of the North European Seafisheries is to be devoted to the utilisation of fish products and this, the first part to appear, is an account of the Fried Fish Trade in Great Britain by W. Loftas, formerly president of the National Federation of Fish Caterers. This work is a veritable pean of the fish caterer, and indeed it is a sound and detailed description of what has developed in the last generation into a first class national business. Mr. Loftas first gives us an historical account of the development of the fried fish trade from its first references in the pages of "Oliver Twist" to the highly specialised organisation of the present day. Oliver's chief claim to fame is his insistence on more porridge: had he been supplied with fried fish, there would have been no end to his importunity,

After an adequate description of the development of the trade Mr.

Loftas passes on to an account of the present position of the fried fish shop and restaurant in our national economy. He estimates there are at present nearly 30,000 fried fish shops and restaurants in Great Britain, of which London and the Manchester districts claim 2,000 apiece. During the Great War these shops utilised 100,000 cwts of fish and 250,000 cwts of potatoes weekly. To prepare this dish over 25,000 cwts of oil and animal fats were required. Taking auxiliary products and the costs of preparation, equipment and renewals into account Mr. Loftas estimates the total value of the trade to be over thirty million pounds sterling per annum. This works out at an average of £ 1000 per annum for each shop, which seems a high average. An estimate of the number of persons employed in the shops is 90,000, and the fish consumed is over one fourth of the total landed in Great Britain, if herring be excluded. The statistics quoted by Mr. Loftas show that the trade is an important one and plays an important part in the social amenities of the working classes, and not only of them but of people of a higher social standing as well, since Mr. Loftas adduces testimonials from Mr. Stanley Baldwin, Miss José Collins and Mr. Robert Blatchford. There is no doubt that the standard of cleanliness, and the quality of the goods supplied is, in the vast majority of fried fish shops, of the highest possible. The reviewer has paid for, but not eaten, fish of the highest price at leading London hotels and restaurants which compared unfavourably with the modest product of the fried fish shop.

Mr. Loftas describes in detail the equipment of a modern establishment and the method of preparing the products for sale, so that his work may be read as a Vade Mecum by inquirers. The illustrations are clear and well designed to prove his contention that the modern fish frier is in every way entitled to the confidence of the large public, on whose patronage the success of the business depends. Full technical details of the actual process of frying are given, as well as hints as to the management of a fish restaurant.

The last chapter is devoted to summarising the laws and regulations under which the business of a fish frier may be carried on.

The whole paper is of such interest and importance that it is to be hoped that the original English work may be published, since in its present state it will be inaccessible to a large number of people to whom it will be of the greatest interest and importance. Mr. Loftas is to be congratulated on presenting us, in a concise and readable, if somewhat eulogistic form, a branch of the fish trade, which has justified itself by the enormous developments it has recently undergone not only in expansion in size but in an advance towards technical perfection which should be a model to many other branches of the catering trade in Great Britain. J. T. J.

F. V. Mortensen und **A. C. Strubberg.** Die dänische Seefischerei. Handbuch der Seefischerei Nordeuropas; herausgeg. von H. Lübbert und E. Ehrenbaum, Bd. VIII, Heft. 2. E. Schweizerbart'sche Verlagsbuchh. Stuttgart, 1931.

As the waters around Denmark are shallow it is not to be wondered at that for many centuries the main feature of the sea-fisheries of Denmark

was a characteristically coastal fishery, only occasionally employing the sparse population along the sandy shores. In an introductory chapter the hydrographical conditions of the Danish waters are briefly sketched, together with a reference to the importance of the sea-grass regions in sheltered waters, which are worth mentioning because of their contributing, both indirectly and directly, to the maintenance of inshore fisheries.

As to the historical and technical development of the fisheries it is explained that for several centuries this industry remained, so to speak, in a dormant state, and that, up to about eighty years ago, only a few fishery centres existed (as Skagen and Limfjord), apart, of course, from the mediaeval Scania fishery on the south-west coast of Sweden (at that time belonging to Denmark), to which dealers from several nationalities, notably the mighty Hansa, were attracted. In other localities fishing was restricted to a small scale with lines and set-nets for plaice, flounder and cod. In the XVIth century Denmark took part in the well-known Bohuslän fishery, and in the period 1615—1640 participated (with Dutchmen and Englishmen) in the Spitsbergen whale-hunt with a centre at Danske Oeer. The depletion of whales in these waters put a stop to Danish whaling, which, though it revived to some extent in the second half of the XVIIIth century, is now completely extinct. Sealing at Jan Mayen, up to 1865, was another occupation, but has practically died out. On the whole the sea-fisheries of Denmark were carried out on a small scale, owing to export difficulties. There were, especially at Bornholm, special well-vessels ("Quatzen") transporting live fish to Copenhagen; these still exist, though now mostly motor-driven. With the middle of the last century this feature gradually changed. In the 'seventies decked boats came into use and the Danish seine ("Snurrevaad") characteristic of the Danish fishery was applied to the capture of plaice outside the Limfjord. The harbour of Esbjerg (built 1870) soon became an important fishing centre of the Jutland coast and has remained so to this day. At the close of the 'eighties cutters from North Jutland began seining for plaice off Esbjerg. Fishing was then restricted to a short distance (not more than 6—8 miles) from shore, extending somewhat further seawards in the Horns Reef area only, and the chief net in use was, as it is now, the Danish seine. At first this net was shot by means of a small rowing boat and then hauled aboard the anchored cutter with a hand winch. This latter was afterwards replaced by a small steam-driven winch till motor power came to the fore. On the strength of all this mechanical aid the auxiliary vessel for shooting the seine was dispensed with. The rapid increase of motor vessels is shown by the following figures: 1895 none, 1920: 200, 1928: 5500, though the majority even of the larger craft still use sails as supplementary power and possess either a well or a hold for the iced catch.

It is remarkable that the Danish fleet of sea-going vessels consists of comparatively small craft, only very few being more than 50 tons; they are mostly motor driven.

After some statistical data of a general nature the authors proceed to discuss the various kinds of fisheries. In value the plaice fisheries stand foremost, 37%, cod and herring come next with 12.6 and 11.7% respectively (all in 1928), while eels contribute very largely (18.3%) in the year named:

fishing for herring and eels is almost wholly confined to the inshore waters. Unlike other North Sea countries it is curious indeed that Denmark did not go in for extensive drift-net fishing nor for trawling, but always clung either to seining in some form or other even on the high seas (and it is well known that Danish cutters nowadays extend their operations far into the North Sea), or to set-nets of all description in the fjords, inlets and straits of the east coasts. This outstanding feature is the natural response of Denmark's maritime development, and consequently of her economical orientation, to the complicated system of straits and sounds to the eastward. Of the fjord fisheries the most important are those of the Limfjord, where the principal kinds of fish are herring and eel, and where, more than at other places, oysters are cultivated.

An extensive chapter is devoted to the description of the various types of fishing vessels and gear. Of the first the principal one is of course the cutter, the classical sea-going motor-driven vessel of the Danish fisherman, the number of which has greatly increased since the war. Many of these are provided with a well. Formerly (about 1890) these vessels fished cod and haddock with long lines in the North Sea, or plaice with the "Snurrevaad" in the Kattegat; nowadays this latter industry has become predominant in the North Sea and its area of exploitation is very much extended. Esbjerg is of course the great fishing centre for these craft. There are also smaller motor vessels for seining, lining or trawling (with the "Scherzeese", a typical Baltic type of net); they are provided with but one mast and look like smacks, operating mostly in the waters of the east coast. Apart from these there are also powerful undecked or half-decked motor boats, using a variety of fixed nets. The gear in use by Danish fisherfolk is of all descriptions. First comes the typical seine for the open sea (plaice seine and haddock seine), but smaller varieties are used in coastal waters, and there are even seines for catching eels or herrings. A peculiar instrument is the "Scherzeese", a kind of trawl, with stunted otter boards; the net itself is long, but generally wingless, and is connected with the boards by lines 40 to 100 m. long, somewhat as in the well-known Vigneron-Dahl method. Beam-trawl and mussel dredges, together with all kinds of small seines, are likewise used. Among purse seines are gigantic nets, even reaching a length of 400 m. and a height up to 45 m. The principal kind of set-nets are weirs in the complicated form of "Bundgarn", an elaborate system of netted cages and chambers, held erect by firmly-driven poles, and often occupying large areas in shallow waters. Nor are pots with all their modifications, as hives and grigs, wanting. And finally we have trammel nets, herring drift-nets (mostly anchored and buoyed) — in short, all those modifications of set-nets which in their more simple forms were most likely invented independently by primitive men all over the world and have undergone only slight alterations since time immemorial.

A further chapter is devoted to harbours and fishing markets, the extension and improvement of which is now being busily attended to. It stands to reason that a very large part of the landings consists of live fish which are transported further inland by the transport vessels ("Quatzen") mentioned before. Preservation of fish, except smoking (herring, eel, mackerel), by no means reaches the high level it does in Norway, for instance.

A few pages give information about fishery acts, subventions by the government to the fishermen and their organisation.

Finally we get a rapid sketch of the fishery near the Faroes. Here the scene and character of the fisheries are altogether different from those of the mother country, except in so far as, at the Faroes, the fishing is sometimes in the hands of people who in their way are entitled to the prerogatives of capitalism. The hardy life of the fisherman is chiefly followed by the inhabitants of these forlorn, wind-swept isles, but the wealth of fish in these waters is exploited chiefly by foreigners, especially by British and German trawlers, while the Faroese themselves use graceful cutters or schooners, now mostly propelled by motor power. Long lines and hand lines are the chief fishing gear of the islanders, with which cod, haddock and saithe are secured. In sheltered fjords herring set-nets are placed. We all know that the Faroes are very productive in klipfish. A somewhat romantic and adventurous touch to the incredibly drab life of these islanders is provided by the occasional appearance of large shoals of whales, especially the smaller kind known as grindwhale (*Globiocephalus melas*) which are driven together and slaughtered. There are also whaling stations operating during the summer months, chiefly dependent on finner whales. The precarious existence of the people inhabiting these bleak shores makes it readily to be understood that sea-going vessels and schooners are owned by "capitalistic" societies or privately privileged people who employ labour, as in great continental ports. There is little organisation among the small fisherfolk who own undecked rowing and sailing boats, or (mostly decked) motor craft. J. J. T.

J. Gray and **S. B. Setna.** The Growth of Fish. IV. The Effect of Food Supply on the Scales of *Salmo irideus*. Journ. Exp. Biology. VIII. 1. pp 55—62. 2 figs. 2 Plates. Cambridge 1931.

There is no need, in this journal, to stress the importance of experiments on the factors affecting scale structure: As the authors remark, surprisingly few experiments have hitherto been made. The authors tried the effect of high and low feeding on two batches of Rainbow Trout, which had previously been reared in the hatchery. Quite definite results were obtained. Abundant food resulted in an increased growth-rate, and the formation of markedly wide circuli; and scarcity of food produced the converse effects. The period of observation was September 1928 to March 1929, and temperature was allowed to follow the seasonal course; but winter produced no effect, neither on the experimental fish, nor on fish receiving the normal hatchery diet. (Nor, in the several fish in the "abundant" tank which spawned during the winter, was there any record on the scales of spawning having taken place).

The fish used numbered 25 in each tank, and the effect on those in the starved tank was slightly complicated by different individual reaction; but the authors' interpretation of their observations appears inevitable. (It is unfortunate that, presumably to save expense, the reader has to be content with typical observations, rather than all the observations. Might this not have been overcome by using the reviewer's scale-tracing method, Graham 1929?)

It is clear that many more experiments are needed before we shall know all about the conditions that affect scale structure. In these experiments on Rainbow Trout, temperature had no effect, but the authors point out that temperature may influence growth in several ways, both accelerating and retarding, the net result depending on equilibrium between conflicting effects. It is also, perhaps, well to remember that a species probably has a characteristic critical temperature. To *S. irideus*, for example, a winter temperature of 5 degrees C. (the lowest monthly mean in GRAY and SETNA'S experiments) may not be an effective retarding factor.

It should be noted that these experiments provide another witness to the correlation between growth-rate and circulus-width. M. G.

P. S. Galtsoff, H. F. Prytherch, and **H. C. McMillin.** An experimental study in production and collection of seed oysters. U.S. Dept. of Commerce. Bureau of Fisheries Document No. 1088. Washington, 1930.

This work affords a striking example of scientific fishery investigation which has yielded immediate results of very great value. In the introductory section of this paper Dr. GALTSOFF explains the problem with which it is concerned, and the lines of attack followed during the last few years under his direction in the North Atlantic coastal waters of America. Though still flourishing by comparison with some European countries, production of market oysters in the United States has nevertheless suffered a definite decline during the last 24 years amounting to over 30%, due mainly to overfishing and pollution of natural beds. Two means of increasing production of seed oysters have to be considered; methods of artifical breeding, and methods for increasing the natural set of spat, sometimes referred to as artificial collection of spat. Artificial breeding has been accomplished on a laboratory scale by two methods in the United States, but at present they are expensive and offer little prospect of application to meet the demand for vast numbers of seed oysters on anything like an economic basis. To find methods of increasing production on natural beds is therefore the urgent problem. The present paper deals with experiments and observations between 1925 and 1928 in three localities; Wareham River and Onset Bay (both in Mass.), and Milford Harbor (Conn.), selected on account of regularity in spat production, which in their waters is independent to a great extent of the general alternation of bad with good seasons characteristic of northern waters.

By the use of crates made of lathing, and piled-up bags made of wire netting filled with shells to serve as collectors in place of shells merely scattered broadcast, it has been found possible not only to increase the set of spat over a given area by as many as thirty times, but also to make use for seed collection of soft muddy bottoms, or shifting sandy bars, where shells scattered in the old way would be unproductive. One wire bag collector, for example, may catch from 5,000 to 25,000 spat. Another form of collector proved satisfactory under certain conditions; the cardboard partition filler for egg boxes, coated with a mixture of lime, sand and cement. Full details are given in a separate report (H. F. PRYTHERCH, "Improved

methods for the collection of seed oysters", U. S. Bureau of Fisheries Document No. 1076, 1930). This collector has an advantage over shells in the ease with which the young oysters can be detached and separated by simply knocking or crushing the partitions.

Descriptions of the various collectors with which the present paper is concerned are clearly illustrated. Numerous tables and figures are presented in connection with hydrographic observations, and the large number of counts of spat necessarily involved.

The outcome of this work cannot fail to be of great value to the fisheries concerned, and may well have a wider application. The question naturally arises: can European countries which are badly in need of seed oysters benefit by these new methods? The frequency with which, in England for example, bad spatting years are experienced on many oyster beds would render expenditure every year on special collectors a great strain on the resources and determination of the oyster grower. We have here a case where accurate prediction of good and bad seasons, already attempted in the case of oysters in the States, would be of the greatest value to many a struggling fishery. H. P. S.

A. C. Robertson and **W. H. Wright.** Investigations upon the deterioration of nets in Lake Erie. U. S. Dep. of Commerce. Bureau of Fish. Doc. No. 1083. Washington, 1930.

The red slime that fouls nets consists of a species of hydra and is harmful only in so far as it harbours destructive bacteria. Gill nets treated with two different dark-coloured preservatives were proved, by practical fishing tests, to catch virtually as many fish as white nets, and to retain their strength longer. Treatment with hot tar is unsatisfactory as the preservative (antiseptic) compounds were soon leached out. Its continued use is due to the incorporation of other toxic agents for which it serves as a vehicle.

Trials were made with various poisons, cuprous oxide, copper oleate, copper resinate, copper salts of naphthenic acids, and mercuric oxide, with petroleum asphalt, coal and wood tars, also kerosene as vehicles. The amounts of copper present, per foot of net, are shown up to 13 weeks immersion in the lake. The period of test was too short. It is considered that copper oleate might be replaced by copper resinate or by a mixture of the two, since the resinate is not slippery. It tends to brittleness, however, hence the value of the mixture. A solution of $1^1/_2$ to 3 pounds of copper resinate per gallon of kerosene is recommended as surpassing copper oleate in preservative action and having none of the disadvantages of the oleate. Inasmuch as the nets were not allowed to rot to destruction, such a conclusion appears to be unjustified. Both lost copper to about the same extent, but the naphthenic acid salt (probably "Cuprinol") retained about twice as much, and appears superior, though the authors ruled it out on account of initial cost, which is an economically unsound conclusion if the preservative action lasts much longer, as their table 4 shows to be the case. W. R. G. Atkins.

Current Bibliography.

Prepared by the Editor with the assistance of Miss THURSBY-PELHAM.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. ALLEN's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted (Price, 1 Kr.).

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

Physical and Biological Conditions in the Sea.

GENERAL HYDROGRAPHY

ANON. Ind. Comite voor Wetenschappel. Onderzoekingen. 1.—3. Bulletin van de Willebrord Snellius Expeditie.

ANON. The Fishery Barograph. Meteorological Office, Air Ministry, London, 1931.

ANON. Carte générale bathymétrique des Océans. 2e Ed. (1912—1930). Musée Océanographique, Monaco, 1931.

ANON. Echolotungen der deutschen Kreuzer "Berlin" (1928) und "Emden" (1930), des Vermessungschiffes "Meteor" (1930) und der Dampfer "Bremen" und "Europa" (1930). Nachr. f. Seefahrer, 1931, Nr. 12, Beiheft.

BEAUGÉ, L. Contribution à l'étude des relations de la Météorologie et de l'Océanographie. Bull. de la Soc. d'Océanogr. de France, XI, 1057—63, 1931.

BEAUGÉ, L. Remarques sur les conditions hydrologiques des Bancs de Terre-Neuve. Rev. des Trav. de l'Office des Pêches Marit. IV, 143—52, 1931.

BERGET, A. Sur les sondages par le son. Annales de l'Inst. Océanogr. X, 1—18, 1931.

BORN, A. Die Entstehung der Ozeane. Meereskunde, XVIII, Nr. 3, 1931.

DEFANT, A. Ergebnisse der "Meteor"-Fahrten in die Isländischen-Grönländischen Gewässer 1929—30. Zschr. f. Ges. f. Erdk., Berlin 1931, Nr. 5—6.

FLEMING, J. A. and PETERS, W. J. Resolutions passed at Leningrad with reference to the proposed Polar Year. Monthly Weather Review, LIX, 17—18, U.S.A. 1931.

GAMS, H. Neue Beiträge zur Geschichte der Ostsee. Internat. Revue der gesamt. Hydrobiol. und Hydrogr. XXVI, 168—78, 1931.

GREGORY, J. W. A Deep Trench on the Floor of the North Sea. Geogr. Journ. LXXVII, 548—51, 1931.

LONG, A. T. The Antarctic Cruise of the Discovery, 1929—1930. Hydrographic Review, VIII, No. 1, 23—27, Monaco, 1931.

LONG, A. T. The Norvegia Antarctic Expedition of 1929—1930. Hydrographic Review, VIII, No. 1, 28—32, Monaco, 1931.

MARGERIE, E. DE. Les dernières feuilles de la Carte Générale Bathymétrique des Océans (Panneau du Pôle Nord). Bull. de l'Inst. Océanogr. No. 280, Monaco, 1931.

POPOV, A. M. Hydrobiological Explorations in the Nordenskiold Sea (Sea of the Brothers Laptev). Internat. Revue der gesamt. Hydrobiol. und Hydrogr. XXV, 462—67, 1931.

PRATJE, O. Einführung in die Geologie der Nord- og und Ostsee (Entwicklung, Formen, Küsten, und Sedimente). Die Tierwelt der Nord- und Ostsee (Grimpe u. Wagler), Teil I. d_1, Leipzig, 1931.

RUNDO, A. Sur l'Évaluation de l'apport des eaux fluviales à la Baltique. III-ème Conférence hydrologique des États baltiques, Warszawa, Mai 1930.

SUDA, K., MATSUDAIRA, Y., KAWASAKI, H., MIZUUTI, M. and TAKAHATA, V. T. The results of the Oceanographical Observations on board R.M.S. "Syunpu Maru" in the Setonaikai (The Inland Sea) in the years 1928, 1929 and 1930 (Part 2). Journ. of Oceanogr., II, 537—43, Imp. Mar. Observ., Kobe, Japan, 1931. (In Japanese, English Résumé.)

SWEDEN. Svenska Hydrografisk-Biologiska Kommissionens Fyrskeppsundersökning, År 1930. Göteborg, 1931.

THORADE, H. Probleme der Wasserwellen. Probleme d. Kosm. Physik, Band XIII—XIV, Hamburg, 1931.

VALLAUX, C. Ice Observation and Patrol in the waters of Newfoundland in 1929. Hydrographic Review, VIII, No. 1, 59—69, Monaco, 1931.

Physics and Chemistry of Sea Water.

KALLE, K. Meereskundliche chemische Untersuchungen mit Hilfe des Zeiss'schen Pulfrich-Photometers. 1. Mitteilung: Apparatur. Ann. der Hydrogr. und Marit. Meteor. LIX, 313—17, 1931.

SUND, O. Colorimetry at Sea, with a Description of a new Colorimeter. Journal du Conseil, VI, 241—45, 1931.

THOMPSON, T. G., JOHNSTON, W. R. and WIRTH, H. E. The Sulfate-Chlorinity Ratio in Ocean Waters. Journal du Conseil, VI, 246—51, 1931.

WATTENBERG, H. Der chemische Aufbau des Atlantischen Ozeans. Finska Kemistsamfundets Meddelanden, No. 2, Helsingfors, 1931.

TEMPERATURE AND SALINITY

BÖHNECKE, G. Beiträge zur Ozeanographie des Oberflächenwassers in der Dänemarkstrasse und Irmingersee. Teil 1. Zugleich Bericht über die Fahrt des "Meteor" im Sommer 1930. Ann. der Hydrogr. und Marit. Meteor. LIX, 317—25, 1931.

BROOKS, C. F. Upwelling Cold Water on the Coast of New Jersey. Monthly Weather Review, LIX, 202, U.S.A. 1931.

DE BUEN, R. Estudio de los metodos que pueden ser empleados en la determinacion de la densidad. Mem. del Cons. Oceanogr. Ibero-Americano. Nr. 3, Madrid.

CLARKE, K. B. Significance of air and sea temperatures obtained on Cruise VII of the Carnegie. Monthly Weather Review, LIX, 183—85, U.S.A. 1931.

HELLAND-HANSEN, B. Temporal Variations in the Ocean's Temperature. Graficas Reunidas, Madrid, 1930.

SUDA, K. and SEKI, K. Report on the Mean Surface Temperatures of the Neighbouring Seas of Japan (September, October, November and December). Journ. of Oceanogr., II, 644—46, Imp. Mar. Observ., Kobe, Japan, 1931. (Chart legends in English.)

THOMPSON, T. G. and WIRTH, H. E. The Specific Gravity of Sea Water at Zero Degrees in Relation to the Chlorinity. Journal du Conseil, VI, 232—40, 1931.

HYDROGEN ION CONCENTRATION AND DISSOLVED GASES

BUCH, K., WATTENBERG, H. and HARVEY, H. W. Apparent Dissociation Constants of Carbon Dioxide in Seawater of Different Salt Contents. Nature, CXXVIII 411—12, 1931.

IBAÑEZ, O. G. On the Colorimetric Determination of pH in Seawater. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 483—88, 1931.

MATSUDAIRA, Y. and TAKAHATA, T. On some experiments on the oxygen titration. Journ. of Oceanogr. II, 697—703, Imp. Mar. Observ., Kobe, Japan, 1931. (In Japanese.)

SEIWELL, H. R. Observations on the Phosphate-Content and Hydrogen-Ion Concentration of the North Sea, the Southern Entrance to the Norwegian Sea and the Water South of Iceland. Journal du Conseil, VI, 213—31, 1931.

PHOSPHATES AND NITRATES

SEIWELL, H. R. Observations on the Phosphate-Content and Hydrogen-Ion Concentration of the North Sea, and Southern Entrance to the Norwegian Sea and the Water South of Iceland. Journal du Conseil, VI, 213—31, 1931.

OTHER CONSTITUENTS

WATTENBERG, H. Über den Kalkgehalt des Ozeanwassers. II. Mitteilung: Die Verteilung im Atlantischen Ozean. Ann. der Hydrogr. und Marit. Meteor. LIX, 273—77, 1931.

Currents.

Anon. Starke SO-liche Stromversetzung zwischen Fehmarnfeuerschiff und Gjedser-Feuer. Hansa, 1931, Nr. 14.

Anon. The present position of our Investigations of Ocean Currents in the Indian Ocean. Marine Observer, VIII, 185—86, 1931.

Anon. Drift Bottles. Ministry of Agriculture and Fisheries, Fisheries Notice, No. 16, London, 1931.

Castens, G. Stromgeschwindigkeiten und Wasserumsätze in den Tiefen des Ozeans. Ann. der Hydrogr. und Marit. Meteor. LIX, 335—39, 1931.

Crestani, G. Floats used in Italy for the Study of Surface currents of the Ocean. Hydrographic Review, VIII, No. 1, 185—89, Monaco, 1931.

Deacon, G. E. R. Velocity of Deep Currents in the South Atlantic. Nature, CXXVIII, 267, 1931.

Ertel, H. Krümmung der Diskontinuitätsflächen in der Atmosphäre und im Ozean. Veröffentl. d. Preuss. Met. Inst. Berlin, 1931. Nr. 380.

Gustafson, T. och Otterstedt, B. Svenska Strommätningar i Kattegat 1930. Svenska Hydrografisk-Biologiska Komm. Skrifter, Ny Serie: Hydrografi X. Göteborg 1931.

Schott, G. Der Peru-Strom und seine nördlichen Nachbargebiete in normaler und anormaler Ausbildung. Ann. der Hydrogr. und Marit. Meteor. LIX, 161—69, 200—13, 240—53, 1931.

TIDES

Admiralty. The Admiralty Tide Tables (Standard Edition) Part I, for the year 1932. London, 1931.

Admiralty. The Admiralty Tide Tables (Abridged Edition) Part I, for the year 1932. London, 1931.

Colborne, D. C. The Diurnal tide in an Ocean bounded by two meridians. Proceed. Roy. Soc. London, CXXXI, Series A, 38—52, 1931.

Pettersson, O. The tidal force. Geogr. Annaler, H. 4, 1930.

Wedemeyer, A. Die Berechnung der Elemente der Gezeitenstromellipsen. Ann. der Hydrogr. und Marit. Meteor. LIX, 339—41, 1931.

WIND

Harrower, J. Northerly winds at Lerwick. Meteor. Mag. LXVI, 140—41, 1931.

LIGHT, COLOUR AND TRANSPARENCY

Somma, A. Expériences sur la transparence des eaux marines. Bull. de la Soc. d'Océanogr. de France, XI, 1070—72, 1931.

Oceanography-Miscellaneous.

Athanassopoulos, G. Sur la production des eaux saumâtres spécialement des formations lagunaires et questions qui s'y rapportent. Bull. de l'Inst. Océanogr. No. 578, Monaco, 1931.

Borowik, J. The Influence of the Vistula on the Gulf of Danzig. Graficas Reunidas, S.A. Madrid, 1930.

Borowik, J. Contributions concernant les effets des eaux de la Vistule sur les rapports dans le Golfe de Dantzig. "Kosmos", Journ. de la Soc. Polonaise des Naturalistes "Kopernik", LV, Fasc. III—IV, Ser. A. Mémoires, 1930. (In Polish, French Résumé.)

Borowik, J. Périodicité des Fluctuations du Reflux de la Vistule. Bull. de l'Inst. Océanogr. No. 579, Monaco, 1931.

Cherubim, R. Über Verdunstungsmessung auf See. Ann. der Hydrogr. und Marit. Meteor. LIX, 325—35, 1931.

Derjugin, K. De l'Influence des détroits et de leur régime hydrologique sur la faune des mers méditerranées et leur évolution ultérieure. Bull. de la Soc. d'Océanogr. de France, XI, 1099—1103, 1931.

Nares, J. D. A method of mooring a floating beacon in deep water. Hydrographic Review, VIII, No. 1, 190, Monaco, 1931.

Schott, G. Der vierte Pacific Science Congress in Batavia-Bandoeng. Ann. der Hydrogr. und Marit. Meteor. LIX, 185—87, 1931.

Plankton.

Barnard, K. H. Crustacea. Part XI. Amphipoda. British Antarctic ("Terra Nova") Exped. 1910, Zoology, VII, 307—454, British Museum, (Nat. Hist.), London, 1930.

Bernstein, T. Pelagic Protists of the Northwest Part of the Kara Sea. Trans. Arctic Inst. III, No. 1, Leningrad, 1931. (In Russian, English Résumé.)

Burfield, S. T. Chaetognatha. British Antarctic ("Terra Nova") Exped. 1910, Zoology, VII, 203—228, British Museum (Nat. Hist.), London, 1930.

Davidson, V. M. Biological and oceanographic conditions in Hudson Bay. 5. The planktonic diatoms in Hudson Bay. Contrib. Canadian Biology and Fisheries, N.S. VI, 495—510, Toronto, 1931.

Friedrich, H. Mitteilungen über vergleichende Untersuchungen über den Lichtsinn einiger mariner Copepoden. Zeitschr. für vergleich. Physiol. XV, 121—38, Berlin, 1931.

Gardiner, A. C. The Validity of Single Vertical Hauls of the International Net in the Study of the Distribution of the Plankton. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 449—72, 1931.

Kalmus, H. Bewegungsstudien an den Larven von *Sabellaria spinulosa* Leuck. Zeitschr. für vergleich. Physiol. XV, 164—92, Berlin, 1931.

Kurasige, H. On a new species of Copepoda, *Calanus Syunpuensis*. Journ. of Oceanogr., II, 685—86, Imp. Mar. Observ., Kobe, Japan, 1931. (In Japanese.)

Lebour, M. V. The Larvae of the Plymouth Galatheidae. II. *Galathea squamifera* and *Galathea intermedia*. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 385—90, 1931.

Leloup, E. Les Porpites de "L'Armauer Hansen". Bull. du Musée Roy. d'Hist. Nat. de Belgique, VII, No. 4, Bruxelles, 1931.

Madsen, H. Bemerkungen über einige entozoische und freilebende marine Infusorien der Gattungen Uronema, Cyclidium, Cristigera, Aspidisca, und Entodiscus gen. nov. Zool. Anz. XCVI, 99—112, 1931.

Marine Biological Association. Plymouth Marine Fauna. Second Edition 1931. Being Notes of the Local Distribution of Species occurring in the Neighbourhood. Marine Biol. Assoc. of the United Kingdom, 1931.

Ostenfeld, C. H. Concluding Remarks on the Plankton collected on the Quarterly Cruises in the Years 1902 to 1908. Cons. Perm. Int. pour l'Explor. de la Mer, Bull. Trimestriel, Quatrième Partie, 601—72, Copenhague, 1931.

Oye, P. van. La fécondation chez les Chaetognathes. Bull. du Musée Roy. d'Hist. Nat. de Belgique, VII, No. 7, Bruxelles, 1931.

Paulsen, O. Études sur le Microplancton de la Mer d'Alboran. Trabajos del Inst. Español de Oceanografia, Núm. 4, Madrid, 1930.

Pirlot, M. *Metalanceola Chevreuxi* genre et espèce nouveaux d'Amphipodes Hypérides. Bull. de l'Inst. Océanogr. No. 572, Monaco, 1931.

Russell, F. S. The Vertical Distribution of Marine Macroplankton. X. Notes on the Behaviour of Sagitta in the Plymouth Area. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 391—414, 1931.

Russell, F. S. Notes on Cyanea caught in the Ring-Trawl in the Plymouth Area during the years 1925 to 1930. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 573—76, 1931.

Schiller, J. Über autochthone pflanzliche Organismen in der Tiefsee. Biologisches Zentralblatt, LI, 329—334, 1931.

Schreiber, E. Über Reinkulturversuche und experimentelle Auxosporenbildung bei *Melosira nummuloides*. Archiv für Protistenkunde, LXXIII, 331—45, Jena, 1931.

Smirnov, S. Zur Kenntnis der Copepodengattung *Eurytemora* Giesbr. Zool. Anz. XCIV, 194—201, 1931.

Smirnov, S. *Cyclopina barentsiana* nov. sp., eine neue Copepoden Art aus dem Barents Meer. Zool. Anz. XCIV, 269—73, 1931.

Suda, K., Matsudaira, Y., Kawasaki, H., Mizuuti, M. and Takahata, V. T. The results of the Oceanographical Observations on board R.M.S. "Syunpu Maru" in the Setonaikai (The Inland Sea) in the years 1928, 1929 and 1930 (part 2). Journ. of Oceanogr. II, 537—43, Imp. Mar. Observ., Kobe, Japan, 1931. (In Japanese, English Résumé.)

Thiel, M. E. Die Hydromedusen der Weddellsee. Internat. Revue der gesamt. Hydrobiol. und Hydrogr. XXV, 305—32, 1931.

Willey, A. Biological and oceanographic conditions in Hudson Bay. 4. Hudson Bay copepod plankton. Contrib. Canadian Biology and Fisheries, N.S.VI, 483—93, Toronto, 1931.

MARINE BACTERIA

Bedford, R. H. The bactericidal effect of the "Prince Rupert" sea-water sampling bottle. Contrib. Canadian Biology and Fischeries, N.S. VI, 423—26, Toronto, 1931.

Young, O. C., Finn, D. B. and Bedford, R. H. A deep sea bacteriological water bottle. Contrib. Canadian Biology and Fisheries, N.S. VI, 417—22, Toronto, 1931.

MARINE ALGAE

Guéguen, E. Les Constituants glucidiques des Algues Rouges. Annales de l'Inst. Océanogr. X, 35—97, 1931.

Bottom Deposits.

Moore, H. B. The Muds of the Clyde Sea Area. III. Chemical and Physical Conditions; Rate and Nature of Sedimentation; and Fauna. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 325—58, 1931.

Moore, H. B. The Specific Identification of Faecal Pellets. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 359—66, 1931.

Bottom Fauna.

GENERAL

Apolloni, N. Ricerche faunistiche nella laguna di Orbetello. Boll. di Pesca, di Piscicolt. e di Idrobiol. VII, 396—414, Roma, 1931.

Brotzky, V. A. Materials for the quantitative evaluation of the bottom fauna of the Storfjord (E. Spitzbergen). Ber. des Wiss. Meeresinst. IV. Lief. 3, 47—61, Moscow, 1931. (In Russian, English Résumé.)

Comm. Int. pour l'Explor. Scient. de la Mer Méditerranée. Faune et Flore de la Méditerranée, 14. Paris, 1931.

Idelson, M. S. A preliminary quantitative evaluation of the bottom fauna of the Spitzbergen bank. Ber. des Wiss. Meeresinst. IV, Lief. 3, 25—46, Moscow, 1931. (In Russian, English Résumé.)

Marine Biological Association. Plymouth Marine Fauna. Second Edition. Being Notes of the Local Distribution of Species occurring in the Neighbourhood. Marine Biol. Assoc. of the United Kingdom, 1931.

Newbigin, M. Life by the Sea-shore. London, 1931. (Rewritten and revised by R. Elmhirst.)

Zenkewitsch, L. A. A quantitative evaluation of the bottom fauna in the sea region about the Kanin peninsula. Ber. des Wiss. Meeresinst. IV, Lief. 3, 5—23, Moscow, 1931. (In Russian, English Résumé.)

SPECIAL GROUPS

Annenkova, N. Die Polychaeten in den Sammlungen der Jakutischen Expedition der Akademie der Wissenschaften der U.S.S.R. Zool. Anz. XCV, 203—05, 1931.

Barnard, K. H. Crustacea. Part XI. Amphipoda. British Antarctic ("Terra Nova") Exped. 1910, Zoology, VII, 307—454, British Museum, (Nat. Hist.), London, 1930.

Berrill, N. J. Studies in Tunicate Development. Part II. — Abbreviation of Development in the Molgulidae. Philosophical Trans. Roy. Soc., Ser. B, No. 468 B, 1931.

Billard, A. Hydroïdes récoltés dans les campagnes du "Pourquoi-Pas?" en 1920, 1921, 1924, 1927, 1929 et 1930. Bull. du Muséum Nation. d'Hist. Nat., Sér. 2, III, 244—50, 1931.

Deichmann, E. The Holothurians of the Western part of the Atlantic Ocean. Bull. Museum Comp. Zool. Harvard College, LXXI, 43—226, Cambridge, Mass., U.S.A. 1930.

Fraser, C. M. Biological and oceanographic conditions in Hudson Bay. 3. Hydroids of Hudson Bay and Hudson Strait. Contrib. Canadian Biology and Fisheries, N.S. VI, 475—81, Toronto, 1931.

Graham, A. On the Morphology, Feeding Mechanisms and Digestion of *Ensis siliqua* (Schumacher). Trans. Roy. Soc. Edinburgh, LVI, 725—51, 1931.

Harant, H. Contribution à l'Histoire naturelle des Ascidies et de leur parasites. Annales de l'Inst. Océanogr. VIII, 231—389, 1931.
Klein, K. Eine Beobachtung an Sepia. Biologisches Zentralblatt, LI, 381—82, 1931.
Lacroix, E. Microtexture du test des Textularidae. Bull. de l'Inst. Océanogr. No. 282, Monaco, 1931.
Leloup, E. Contribution à la Repartition des Cerianthaires dans le Sud de la Mer du Nord. Bull. du Musée Roy. d'Hist. Nat. de Belgique, VII, No. 2, Bruxelles, 1931.
Losina-Losinsky, L. K. Pantopoda, gesammelt von den Expeditionen des Wissenschaftlichen Meeresinstituts in den Jahren 1921, 1923. Ber. des Wiss. Meeresinst. IV, Lief. 3, 63—87, Moscow, 1931. (In Russian, German Résumé.)
Lüders, K. und Trusheim, F. Beiträge zur Ablagerung mariner Mollusken in der Flachsee. II. Trusheim, F. Versuche über Transport und Ablagerung von Mollusken. Senckenbergiana, XIII, 124—39, Frankfurt a. M., 1931.
MacGinitie, G. E. The Egg-laying Process of the Gastropod, *Alectrion fossatus*, Gould. Ann. and Mag. of Nat. Hist., Ser. 10, VIII, 258—61, 1931.
Maldura, C. Relazione sulla crociera compiute in Cirenaica per le indagini sulla pesca delle spugne. Boll. di Pesca, di Piscicolt. e di Idrobiol. VII, 415—44, Roma, 1931.
Nicol, E. A. T. The feeding mechanism, formation of the tube, and physiology of digestion in *Sabella pavonina*. Trans. Roy. Soc. Edinburgh, LVI, 537—98, 1931.
Orton, J. H. and Moore, H. B. Occurrence of *Protodrilus flavocapitatus* at Port Erin. Nature, CXXVII, 780—81, 1931.
Poisson, R. et Maury, A. *Arcturinella banyulensis* nov. gen., nov. sp., Crustacé Isopode nouveau (tribu des Valvifera, famille des Arcturidae), capturé à Banyuls (Pyr. Orientales). Bull. de l'Inst. Océanogr. No. 573, Monaco, 1931.
Schulz, E. Beiträge zur Kenntnis mariner Suctorien. Zool. Anz. XCVI, 95—99, 1931.
Teissier, G. Étude expérimentale du développement de quelques Hydraires. Ann. des Sciences Naturelles, Zoologie, Sér. X, Tome XIV, 5—60, Paris, 1931.
Thomson, J. A. and Rennet, N. Alcyonaria, Madreporaria and Antipatharia. Australasien Antarctic Expedition, 1911—14. Scient. Reports, Series C: Zoology and Botany, Vol. 9, Part 3, Sydney, New South Wales, 1931.
Yonge, C. M. The Significance of the Relationship between Corals and Zooanthellae. Nature, CXXVIII, 309—11, 1931.

Fishery Investigations.

GENERAL

Angelis, R. de. I nostri paesaggi e i nostri centri pescherecci. Il Golfo di Salerno. Boll. di Pesca, di Piscicolt. e di Idrobiol. VII, 507—16, Roma, 1931.
Anon. Recommandations et Programmes (Mars 1931). Cons. Perm. Int. pour l'Explor. de la Mer, Rapp. et Proc. Verb., LXXIV, 31—101, Copenhague, 1931.
Borowik, J. Revue des Travaux de l'Institut National Polonais d'Économie Rurale accomplies dans le domaine de la Pisciculture au cours de la période annuelle 1929—30. Bydgoszcz, 1930. (In Polish, French Résumé.)
Fischer, E. Die Fischerei-Forschungsinstitute in Deutschland. a) Für Seefischerei. Jahresber. über die Deutsche Fischerei, 1930, 244—52, Berlin, 1931.
Fischer, E. Die wichtigste Fischereiliteratur des Jahres 1930. A. Seefischerei. Jahresber. über die Deutsche Fischerei 1930, 258—66, Berlin, 1931.
Hachey, H. B. and Walker, S. J. Biological and oceanographic conditions in Hudson Bay. 2. Report on the Hudson Bay Fisheries Expedition of 1930. A. Open water investigations with the S. S. Loubyrne. B. Investigations at Churchill, Manitoba. Contrib. Canadian Biology and Fisheries, N.S. VI, 463—74, Toronto, 1931.
Huntsman, A. G. Biological and oceanographic conditions in Hudson Bay. 1. Hudson Bay and the determination of fisheries. Contrib. Canadian Biology and Fisheries, N.S. VI, 455—62, 1931.
Police, G. La pesca nei mari di Calabria. Le condazioni dei mari di Calabria rispetto alla pesca. Boll. di Pesca, di Piscicolt. e di Idrobiol. VII, 517—59, 1931.
Quibbon. Science and the Fishing Industry. Fish Trades Gazette, 27, 25-VII-31.

COMMERCIAL FISHERIES

Altazin, E. La Marée. Sa Conservation — Sa Consommation. Annales de l'Inst. Océanogr. VIII, 393—416, 1931.

Borowik, J. Dix Années de Pêche Maritime en Pologne (1920—1930). Tables Statistiques. Bydgoszcz, 1930.

Borowik, J. Contributions to the Study of Methods of Fish Protection. Archives d'Hydrobiol. et d'Ichthyologie, V, 315—32, 1930. (In Polish.)

Eichelbaum, E. Die Seefischerei. Jahresber. über die Deutsche Fischerei, 1930, 11—110, Berlin, 1931.

England. Report on Sea Fisheries for the year 1930. Ministry of Agriculture and Fisheries, London, 1931.

Fenaroli, L. Notizie sulla pesca nel Mossamedes (Angola) e sui prodotti derivati, olio di pesce e guano. Elenco delle specie di interesse economico e omologazione dei nomi locali portoghesi. Boll. di Pesca, di Pisciolt. e di Idrobiol. VII, 448—56, Roma, 1931.

Fischer, E. Die Kutter-Hochseefischerei und Küstenfischerei in Nord- und Ostsee. Jahresber. über die Deutsche Fischerei, 1930, 176—94, Berlin, 1931.

Loftas, W. Bratfischhandel in Grossbritannien. Handb. der Seefischerei Nordeuropas (Lübbert u. Ehrenbaum), IX, Heft 3 a, Stuttgart, 1931.

Lübbert, H. Umfang und Methoden der französischen Seefischerei. Der Fischerbote, XXIII, 189—98, 1931.

Mortensen, F. V. Sea Fisheries of Denmark: One of the Nation's Most Important Industries. Fishing News, 28—29, 1-VIII-31.

Neumann, J. Die deutsche Hochseefischerei. Jahresber. über die Deutsche Fischerei 1930, 161—70, Berlin, 1931.

Notevarp, O. Statens Fiskeriforsøksstasjons virksomhet. Årsberet. vedkom. Norges Fiskerier 1930, Nr. 3, Bergen, 1931.

Poland. Pêches Maritimes Polonaises. IV. (1928—1930). Bydgoszcz, 1931.

Reay, G. A. Cold Storage of Fish. Fish Trades Gazette, 24—25, 12-IX-31.

Rosén, N. Sveriges in- och utförsel av fiskeriprodukter 1930. Ny Svensk Fiskeritidskrift, Nr. 17, 161—70, 1931.

Schnakenbeck, W. Die bisherigen Erfahrungen mit der Verwendung von Flugzeugen im Dienste der Seefischerei. Der Fischerbote, XXIII, 275—78, 1931.

Scotland. Forty-ninth Annual Report of the Fishery Board for Scotland, being for the year 1930. Edinburgh, 1931.

Seligo, A. Die Seefischerei von Danzig. Handb. der Seefischerei Nordeuropas (Lübbert u. Ehrenbaum), VIII, Heft 7, Stuttgart, 1931.

Steinert, H. Die neuere Entwicklung der niederländischen Seefischerei. Der Fischerbote, XXIII, 220—27, 1931.

Sund, O. Die Lofotfischerei. Der Fischerbote, XXIII, 249—58, 1931.

FISHING GEAR

Anon. Developing the Perfect Trawl Net. Fish Trades Gazette, 33—34, 25-VII-31.

Anon. The History of Trawling. Part One: "The Origin of Trawling". Fish Trades Gazette, 33—34, 29-VIII-31.

Atkins, W. R. G. The Deterioration of Fabrics Exposed on a Roof after Treatment with Fishing-net Preservatives. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 473—78, 1931.

Borowik, J. Études concernant l'Influence des engins sur la composition de la pêche. Bydgoszcz, 1931. (In Polish.)

Meyer, P. F. Die im Jadebusen gebräuchlichen Granatfanggeräte und ihre Eignung für den Fang. Mitt. des Deutsch. Seefisch. Ver. XXXXVII, 264—74, 1931.

Rosén, N. En ny trål. Ny Svensk Fiskeritidskrift, Nr. 18, 172—73, 1931.

Fishes.

GENERAL

Arcidiacono, F. La pesca del pesce vacca (*Hexanchus griseus* L.) nella marine di Riposto. Boll. di Pesca, di Piscicolt. e di Idrobiol. VII, 608—12, Roma, 1931.

Bigelow, H. B. and Schroeder, W. C. A rare Bramid Fish (*Taractes princeps* John-

son) in the Northwestern Atlantic. Bull. Museum Com. Zool. Harvard College, LXIX, 41—50, Cambridge, Mass., U.S.A. 1929.

Binaghi, G. Osservazioni sul rapporto ponderale tra soma e fegato nei Teleostei. R. Com. Talasso. Ital., Mem. CLXXXIV, Venezia, 1931.

Borodin, N. A. Atlantic Deep-Sea Fishes. Bull. Museum Comp. Zool., Harvard College, LXXII, 55—89, Cambridge, Mass., U.S.A. 1931.

de Buen, F. *Lebetus* Whinter 1877, *Odondebuenia* nov. gen. y *Cabotia* nov. gen. (Gobiidae de Europa). Trabajos del Inst. Español de Oceanografia, Núm. 5, Madrid, 1930.

Chabanaud, P. A propos de la nomenclature des poissons de l'ordre des *Heterosomata* Cope. Bull. du Muséum Nation. d'Hist. Nat. Ser. 2, III, 302—03, 1931.

Comm. Int. pour l'Explor. Scient. de la Mer Méditerranée. Faune et Flore de la Méditerranée, 14. Paris, 1931.

Denker. Über das Hörvermögen der Fische. Acta Oto-Laryngol. XV, 247—60, 1931.

Giltay, L. Poissons recueillis au Gröenland Oriental en 1927 at en 1928, par. M. Dumbrava. Bull. du Musée Roy. d'Hist. Nat. de Belgique, VI, No. 22, Bruxelles, 1930.

Giltay, L. Note sur quelques poissons de la Sibérie Oriental. Bull. du Musée Roy. d'Hist. Nat. de Belgique, VI, No. 23, Bruxelles, 1931.

Grundfest, H. The relative effectiveness of spectral radiation for the vision of the Sunfish *Lepomis*. Proc. Nat. Acad. Sci. Philad. XVII, 1931.

Matheson, C. A Rare British Fish: Relative of the Sea Serpent in the Trawl. Fishing News, 30, 13-VI-31.

Metzner, H. und Röhler, E. Neue Untersuchungen über die Zusammensetzung der Körpersubstanz einiger Seefische. Der Fischerbote, XXIII, 235—45, 1931.

Miles, W. R. Behavior of Fish in Elevated Water-Bridges connecting Adjoining Aquaria. J. Comp. Psychol. XII, 123—32, 1931.

Norman, J. R. A History of Fishes. London, 1931.

Roule, L. Le phénomène de l'anorexie génétique chez les poissons. C. R. Soc. Biol. CV, 675—6, 1930.

Roule, L. et Angel, F. Observations et rectifications concernant divers Poissons recueillis par S.A.S. le Prince Albert Ier de Monaco au cours des Campagnes 1911 à 1914. Bull. de l'Inst. Océanogr. No. 281, Monaco, 1931.

Schnakenbeck, W. Zum Rassenproblem bei den Fischen. Zeitschr. f. Morphologie und Ökologie der Tiere, XXI, 409—566, 1931.

Steven, G. A. Rays and Skates of Devon and Cornwall. Methods of Rapid Identification on the Fish Market. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 367—78, 1931.

Verrier, M. La vision chez les poissons. Bull. Assoc. français Avancement des Sciences, LX, 165—77, 1931.

Verrier, M. Sur les organes sensoriels des poissons de grande profondeur. C. R. Acad. Sci. Paris, CXCII, 297—9, 1931.

Warner, L. H. The Problem of Color Vision in Fishes. Quart. Rev. Biology, VI, 329—48, 1931.

Yonge, C. M. Digestive Processes in Marine Invertebrates and Fishes. Journal du Conseil, VI, 175—212, 1931.

EGGS AND LARVAE

Desbrosses, P. Note sur l'oeuf de la Raie Chardon *Raia fullonica* L. Bull. de la Soc. Zool. de France, LVI, 15—18, Paris, 1931.

de Gaetani, D. Uova, sviluppo embrionale e stadi post-embrionali negli *Sparidi*. 1. *Oblata Melanura* Cuv. R. Com. Talssso. Ital., Mem. CLXXXIII, Venezia, 1931.

Inaba, D. On some Teleostean Eggs and Larvae found in Mutzu Bay. Records of Oceanographic Works in Japan, III, 53—62, Tokyo, 1931.

Roule, L. Les poissons et le monde vivant des eaux: études ichthyologiques et philosophiques. (Les oeufs et les nids, Tome 4). Paris, 1931.

Sanzo, L. Uova, stadi embrionali e post-embrionali di *Naucrates ductor* L. R. Com. Talasso. Ital., Mem. CLXXXV, Venezia, 1931.

Sparta, A. Contributo alla conoscenza di uova e larve nei Labridi. II. Uova e larve di *Crenilabrus ocellatus* Forsk. R. Com. Talasso. Ital., Mem. CLXXXII, Venezia, 1931.

Tåning, Å. V. Postlarval Stages of *Bathylagus* from the North Atlantic. Vidensk. Medd. fra Dansk. Naturh. Foren. Bd. 92, 269—74, 1931.

FISH HATCHING

Lechler, H. Zur Frage der Seeforellen- und Hechterbrutung. Allgemeine Fischerei-Zeitung, LVI, 8—10, 1931.

FISH PARASITES AND DISEASES

Desbrosses, P. Traumatismes de la bouche chez la Dorade commune. Les problèmes qu'ils posent, concernant la biologie de cette espèce. Rev. des Trav. de l'Office des Pêches Marit. IV, 183—96, 1931.

Guiart, J. Considérations historiques sur la nomenclature et sur la classification des Tétrarhynques. Bull. de l'Inst. Océanogr. No. 575, Monaco, 1931.

Leloup, E. Deux Cas d'Épibiose de l'Hydropolype, *Campanularia johnstoni* Alder. Bull. du Musée Roy. d'Hist. Nat. de Belgique, VI, No. 19, Bruxelles, 1930.

Mackinnon, D. L. and Ray, H. N. Notes on the Ciliate *Boveria stevensi* Issel from *Galeomma turtoni* Sowerby at Plymouth. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 577—82, 1931.

Manter, H. W. Some Digenetic Trematodes of Marine Fishes of Beaufort, North Carolina. Parasitology, XXIII, 396—411, 1931.

Patzelt, H. Dos Trematodos parasitos de *Sardinella aurita* Cuv. y Val., *Aphanurus stossichi* Mont. y *Hemiurus appendiculatus* Rud. Notas y Resúmenes, Ser. II, Núm. 45, 1930.

Petruschewsky, G. K. Über die Verbreitung der Plerocercoide von *Diphyllobothrium latum* in den Fischen der Newabucht. Zool. Anz. XCIV, 139—47, 1931.

Pigulewsky, S. W. Neue Arten von Trematoden aus Fischen des Dnjeprbassins. Zool. Anz. XCVI, 9—18, 1931.

Reichenow, E. Parasitische Flagellata. Die Tierwelt der Nord- und Ostsee (Grimpe u. Wagler), Teil II. e_1, Leipzig, 1931.

Zuelzer, M. Spirochaeta. Die Tierwelt der Nord- und Ostsee (Grimpe u. Wagler), Teil II. f, Leipzig, 1931.

AQUARIUM EQUIPMENT

Atkins, W. R. G. Note on the Condition of the Water in a Marine Aquarium. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 479—82, 1931.

AGE-DETERMINATION

Monastyrsky, G. N. Über Methoden zur Bestimmung des linearen Wachstums des Fische nach der Schuppe. Reports Scient. Inst. of Fisheries, V, No. 4, 3—44, Moscow, 1930. (In Russian, German Résumé.)

PLAICE AND OTHER PLEURONECTIDS

Anon. Gesetz über das zwischen Deutschland, Dänemark, Danzig, Polen und Schweden geschlossene Übereinkommen über die Regelung der Schollen- und Flundernfischerei in der Ostsee vom 9. August 1930, nebst den Verordnungen vom 24. Februar 1931 und 16. März 1931 und der Bekanntmachung vom 21. März 1931. Jahresber. über die Deutsche Fischerei 1930, 276—80, Berlin, 1931.

Borowik, J. Pêches des pleuronectes à la côte polonaise. Pêches Maritimes Polonaises, IV, 169—225, Bydgoszcz, 1931. (In Polish, French Résumé.)

Dixon, B. Quelques observations sur la rapidité de croissance de Pleuronectes dans le golfe de Dantzig. Mém. de l'Inst. Nat. Polonais d'Economie Rur. à Pulawy, Nr. 160, Pulawy, 1930.

Jenkins, J. T. The Plaice Fisheries: Alarming Trend of Post-War Years. Fish Trades Gazette, 30, 30-V-31.

Jensen, A. J. C. Investigations of the Plaice Stock in the Southern Horns Reef Area in the years 1928—1930. Meddel. fra Komm. for Danmarks Fiskeri- og Havundersøgelser, Serie: Fiskeri. Bind IX, Nr. 2, København, 1931.

Kändler, R. Erneuerung und Nutzung des Schollen- und Flundernbestandes im Gebiet der Oderbank. Ber. der Deutsch. Wiss. Komm. für Meeresforschung, N.F. VI, 22—61, Leipzig, 1931.

Ssytsch, N. W. Ueber *Pleuronectes flesus* des Barenz und des Weissen Meeres. Reports Scient. Inst. of Fisheries, V, No. 4, 87—116, Moscow, 1930. (In Russian.)

COD

Beaugé, L. Les différentes races de morues. Rev. des Trav. de l'Office des Pêches Marit. IV, 197—201, 1931.

Jeffers, G. W. Observations on the Cod Fishery in the Strait of Belle Isle. Bull. XVIII of the Biol. Board of Canada, Toronto, 1931.

Kusmin-Karawajew, G. A. Beiträge zur Biologie von *Eleginus navaga* P. des Weissen Meeres. Reports Scient. Inst. of Fisheries, V, No. 4, 55—79, Moscow, 1930. (In Russian.)

Kusmin-Karawajew, G. A. Jungfische von *Eleginus navaga* P. der Ostküste von Murman. Reports Scient. Inst. of Fisheries, V, No. 4, 81—86, Moscow, 1930. (In Russian.)

Schmidt, Johs. Les nouvelles recherches sur les migrations de la morue dans le nord de l'Atlantique. La Pêche Maritime, la Pêche Fluviale et la Pisciculture, XIV, 1009—10, 11-X-31.

Sund, O. Die Lofotfischerei. Der Fischerbote, XXIII, 249—58, 1931.

HAKE

Anon. Les recherches sur la biologie du merlu par le "marquage". La Pêche Maritime la Pêche Fluviale et la Pisciculture, XIV, 989, 4-X-31.

HERRING

Anon. Die schwedische Heringsfischerei und der Trawlheringsfang. Der Fischerbote XXIII, 160—61, 1931.

Borodatowa, S. A. Die Heringe des Barenz-Meeres. Reports Scient. Inst. of Fisheries, V, No. 4, 45—54, Moscow, 1931. (In Russian.)

Graham, M. Some Problems in Herring Behaviour. Journal du Conseil, VI, 252—65, 1931.

Hodgson, W. C. East Anglian Herring Fishery: This Year's Prospects examined. Fishing News, 28—29, 22-VIII-31.

Lissner, H. Die Fangplätze der Deutschen grossen Heringsfischerei. Der Fischerbote, XXIII, 157—60, 1931.

Lissner, H. Haunts of the Herring: Where the German Fleet is told to operate. Fishing News, 29, 4-VII-31.

Lissner, H. Die Deutsche Heringsfischerei mit Treibnetzen im Jahre 1930. Ber. der Deutsch. Wiss. Komm. für Meeresforschung, N. F. VI, 1—21, Leipzig, 1931.

Muzinic, S. Der Rhythmus der Nahrungsaufnahme beim Hering. Ber. der Deutsch. Wiss. Komm. für Meeresforschung, N. F. VI, 62—64, 1931.

Rounsefell, G. A. Fluctuations in the supply of Herring (*Clupea pallasii*) in Southeastern Alaska. Bull. Bureau of Fisheries, XLVII, 15—56, U.S.A. 1931.

Rudolph, H. Wieder ein Heringszwitter. Zool. Anz. XCV, 37—41, 1931.

Steffen, W. Die grosse Heringsfischerei. Jahresber. über die Deutsche Fischerei 1930, 171—75, Berlin, 1931.

Schnakenbeck, W. Zum Rassenproblem bei den Fischen. Zeitschr. f. Morphologie und Ökologie der Tiere, XXI, 409—566, 1931.

Stewart, J. I. The Scottish Herring Fishing Industry and the Factors which affect the Market for Cured Herrings. Scottish Geogr. Mag. XLVII, 219—227, 1931.

Tchougounoff, N. L. On the contemporary herring fisheries in North Sea. Reports 3rd Caspian Herring Exped. Vol. 1, 1930.

PILCHARD, SPRAT AND ANCHOVY

Anon. Die Sardinenfischerei in Frankreich. Der Fischerbote, XXIII, 230—32, 1931.

Arné, P. Contribution à l'étude de l'Anchois du Golfe de Gascogne (*Engraulis encrassicholus* L.). Rev. des Trav. de l'Office des Pêches Maritimes, IV, 153—82, 1931.

Clark, F. N. Dominant size-groups and their influence in the fishery for the California Sardine (*Sardina caerulea*). Division of Fish and Game of California, Fish. Bull. No. 31, 7—44, Sacramento, 1931.

Ramalho, A. et Boto, R. Sur la Relation entre la Croissance de la Sardine et celle des écailles. Trav. de la Stat. de Biol. Marit. de Lisbonne, No. 26, 1931.

MACKEREL

Jensen, A. J. C. Udsigterne for Makrelfiskeriets Udbytte i Sundet i Efteraaret 1931. Dansk Fiskeritidende, Nr. 35, 445—46, 1931.

Sette, O. E. Outlook for the Mackerel Fishery in 1931. U. S. Dept. of Commerce, Bureau of Fisheries, Fishery Circular No. 4, 1931.

EELS

Hornyold, A. G. Le sexe, la croissance et la formation des zones des écailles de la petite Anguille jaune des étangs de Thau, d'Ingril, de Vic, et de Vaccares. Bull. de la Soc. Centr. d'Aquiculture et de Pêche, XXXVIII, 35—43, 1931.

Jensen, A. J. C. Om Udsigterne for Blankaalsfiskeriet i Efteraaret 1931. Dansk Fiskeritidende, Nr. 34, 428—29, 26-VIII-31.

Schmidt, Johs. Eels and Conger Eels of the North Atlantic. Nature, CXXVIII, 602—04, 1931.

Sklower, A. Die Bedeutung der Schilddrüse für die Metamorphose des Aales und der Plattfische. Forschungen und Fortschritte, November 1930.

Freshwater Fish.

Anon. Wanderungen von Ostseelachsen. Der Fischerbote, XXIII, 278—81, 1931.

Bhatia, D. A critical study of the scales of two specimens of starved and excessively fed Trout — *Salmo irideus*. Journal du Conseil, VI, 266—72, 1931.

Dixon, B. Sea Trout of Reda River. Mém. de l'Inst. Nat. Polonais d'Économie Rur. à Pulawy, XI, 218—263, Pulawy, 1930.

Henking, H. Untersuchungen an Salmoniden. Teil II. Cons. Perm. Int. pour l'Explor. de la Mer, Rapp. et Proc.-Verb., LXXIII, Copenhague, 1931.

Lima, J. A. P. de. Truite à colonne vertébrale raccourcie. Bull. de la Soc. Portugaise des Sciences Nat., Tome XI, 47—48, 1930.

Otterstrøm, C. V. Die Turbinen und die abwärts wandernden jungen Lachse und Forellen. Journal du Conseil, VI, 273—86, 1931.

Sklower, A. Die Perteltnicker Forellenversuche und ihre praktische Bedeutung. Allgemeine Fischerei-Zeitung, Nr. 4 und 5, 1931.

Willer, A. und Quednau, W. Untersuchungen über den Lachs (*Salmo salar* L.) I. Zeitschr. für Fischerei und deren Hilfswissenschaften, XXIX, 185—215, 1931.

POLLUTION

Ivlev, V. S. Zum Studium der Biologie des Flussbrandes des Flusses Ob. Zool. Anz. XCVI, 23—30, 1931.

Scotland. Second Report of the Scottish Advisory Committee on Rivers Pollution Prevention. River Esk (Midlothian). Dept. of Health for Scotland, Edinburgh, 1931.

Oysters and other Lamellibranchs.

Borde, F. Le captage du naissain dans le bassin d'Arcachon. La Pêche Maritime, la Pêche Fluviale et la Pisciculture, XIV, 617—19, 1931.

Hopkins, A. E. Temperature and the Shell Movements of Oysters. Bull. Bureau of Fisheries, XLVII, 1—14, U.S.A. 1931.

Hopkins, A. E. Factors influencing the spawning and setting of Oysters in Galveston Bay, Tex. Bull. Bureau of Fisheries, XLVII, 57—83, 1931.

McMillin, H. C. and Bonnot, P. Oyster Culture in California. California Fish and Game, XVII, 246—51, San Francisco, 1931.

Orton, J. H. On the Effect of the Severe Winter of 1928—1929 on the Oyster Drills with a Record of Five Years Observations on Sea-Temperature on the Oyster-beds of the Blackwater Estuary. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 301—14, 1931.

Orton, J. H. and Amirthalingam, C. Observations and Experiments on Sex-Change in the European Oyster (*O. edulis*). Part II. On the Gonad of Egg-Spawning Individuals. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 315—24, 1931.

Stephen, A. C. Notes on the Biology of Certain Lamellibranchs on the Scottish Coast. Journ. Mar. Biol. Assoc. U.K., N.S. XVII, 277—300, 1931.
Voisin, P. La maladie des huîtres de Zélande. Rev. des Trav de l'Office des Pêches Marit. IV, 221—22, 1931.
Voisin, P. Quelques observations sur l'absence de "verdeur" dans la région de Marennes. Rev. des Trav. de l'Office des Pêches Marit. IV, 223—30, 1931.

Crustacea.

Ehrenbaum, E. Die Wollhandkrabbe auf der 37. Wanderausstellung der D.L.G. Der Fischerbote, XXIII, 163—64, 1931.
Heldt, H. et Heldt, H. (Mme). Les Langoustines (*Nephrops norvegicus* Leach) dans les Mers Tunisiennes. Stat. Océanogr. de Salammbô, Notes No. 16, 1931.

Whales and Seals.

Gray, R. W. The Colour of the Greenland Sea and the Migrations of the Greenland Whale and Narwhal. Geogr. Journ. LXXVIII, 284—90, 1931.

Biological-Miscellaneous.

Renouf, L. Preliminary Work of a new Biological Station (Lough Ine, Co. Cork, I.F.S.). Journ. Ecol. XIX, 410—38, 1931.
Schlieper, C. Über das Eindringen mariner Tiere in das Süsswasser. Biologisches Zentralblatt, LI, 401—12, 1931.
Yonge, C. M. Digestive Processes in Marine Invertebrates and Fishes. Journal du Conseil, VI, 175—212, 1931.

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